ILLUMINATING ENGINEERING

NOVEMBER 1951

An Analysis of Fluorescent Luminaire Brightness
Office Combines Troffers and Luminous Ceiling
F-Lamp Performance on Sequence-Start Ballasts
Lighting Coordinated with Office Structure
Light and Sound Absorption in Offices
Government Office Environment
Engineering for Office Comfort

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

all 4 advantages you want

in a fluorescent lampholder...

exclusive with Benjamin... *yours at no extra cost!*

In a fluorescent lampholder, the four advantages you want most... the four features that you would include were you designing a lampholder of your own... are *yours* with Benjamin "Springlox." Benjamin brings you this exclusive, patented advancement at no additional lighting equipment cost!

These four most-wanted features bring you everything you require of a fluorescent lampholder: longer life, better electrical contact, speedier relamping and all-around simpler, quicker, safer lighting maintenance.

You get these four most-wanted features exclusively with Benjamin. They are yours as "standard equipment" with every Benjamin Industrial Fluorescent Lighting Unit, whether it uses two T12 lamps or three, bi-pin or single-pin lamps, for individual units or continuous line construction.

*Exclusive with all** BENJAMIN FLUORESCENT UNITS

BENJAMIN "Springlox" lampholders

sold exclusively through electrical distributors

1 "Built to take it" RUGGEDNESS Practically indestructible ALL-METAL construction. NO BREAKAGE... NO out-of-service time due to socket failure. Lamps CUSHIONED against shock and vibration.

2 SAFETY Whether installed in a steel mill or office, lamps cannot drop out or be shaken loose, because "Springlox" is SELF-ADJUSTING for slight differences in lamp length.

3 "Quick-in, quick-out" LAMP SERVICING Makes lamp servicing simpler for all T12 fluorescent lamps. "Finding ring" makes possible ONE-HAND lamp insertion of bi-pin lamps.

4 "Never-fail" ELECTRICAL CONTACT Never fails to make contact the *first time*. "Easy-make, easy-break" circuit switch built into single-pin type. Separate springs for electrical contact and locking compression.

Single-pin type "Springlox" for 2 or 3 lamps

Bi-pin type "Springlox" for 2 or 3 lamps

transparent view of "push end" shows how flexible spring base simplifies lamp insertion.

*"Springlox" lampholders are designed to accommodate all T12 Lamps for industrial use.

Send for **FREE "SPRINGLOX" DATA BULLETIN!** Tells you more about time and labor savings made possible by "Springlox"-equipped Benjamin Fluorescent Lighting Units. For your free copy, write Benjamin Electric Mfg. Co., Dept. I, Des Plaines, Ill.

50 YEARS

R54008

"Cuts cost three ways"

with Westinghouse MERCURY lighting

A tank company in Illinois ran cost studies on the new Westinghouse Mercury Lighting System. Results:

1. Operating costs are reduced because mercury vapor produces more light per dollar than any other light source.
2. Maintenance costs are cut because it takes fewer fixtures to produce high levels of illumination than with any other lighting system.
3. Lamp replacement costs are lower, because mercury vapor lamp life is 5,000 hours—5 times longer than the most efficient incandescent lamp.

This is one of hundreds of "time-tested" installations. Investigate the Westinghouse Mercury Vapor Line: 400, 1000 and 3000-watt units for low or high-bay areas . . . open or closed fixtures for clean or dirty locations . . . low or high-voltage ballasts for any distribution system.

Send for B-4727, **"Westinghouse Lighting at Work" in every industrial area.** Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE.. IF IT'S

Westinghouse

LIGHTING DIVISION

Edgewater Park, Cleveland

J-04295

Iowa Power & Light Company, Des Moines, Ia. Architect-Engineer: Elmer Borg, Brooks-Borg, Architects, Des Moines. Electrical Contractor: Johnson Electric Company, Des Moines. Area: Approximately 385 square feet. Wattage: 2208. Watts per square foot: 5.7. Intensity — all lamps on: Average on desk, 101 Footcandles in Service; Average in entire room, 96 Footcandles in Service. Luminous Ceiling: Six panels, 48" sq.; 48 — 4' Slimline strip fixtures, 96 — #9015 Holophane Lenses.

A Luminous Ceiling by Litecontrol

For a Utility President's Office

This smart, modern executive office — featuring Litecontrol's Luminous Ceiling with Holophane #9015 low brightness lenses — is unusual for its attractive appearance, for its good functional design. Its Litecontrol-planned wiring permits either of two levels of intensity at the flick of a switch.

This Luminous Ceiling increases the beauty of the room, sheds well-distributed light on the toughest executive problems. MORAL: when you have problems . . . *hard-to-handle lighting problems* . . . you'll save time and trouble by contacting your nearest LITECONTROL Representative.

LITECONTROL *Fixtures*

KEEP UPKEEP DOWN

LITECONTROL CORPORATION, 36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

NOVEMBER
1951

Vol. XLVI
No. 11

Troffers and Luminous Ceilings Go Well Together — R. L. Oetting — 543
Engineering for Lighting Comfort — 546
Lighting Data Sheet—Series XVI Louvered-Ceiling Office (13-69) — 548
Public Buildings Service in the Lighting Field — Thomas F. Coghlan — 549
Lighting Coordinated With Structure — 557
Fluorescent Lamp Performance on Sequence-Start Ballasts — D. D. Hinman, R. L. Keiffer, and C. E. Strecker — 560
Light and Sound Absorption — T. D. Wakefield — 567
An Analysis of Fluorescent Luminaire Brightness — John J. Neidhart — 569
Light, Color, and Environment in Government Offices — L. M. Endres — 577
Loss of Visibility Due to Reflections of Bright Areas — H. M. Sharp and J. F. Parsons — 581
Yuletide Highlights — 584
Current Recommended Practice for Sports Lighting — Part I — 585
TELECAST — Lighting News of Current Interest — 5A
Lighting Calendar, 7A; About People, 15A; Obituaries, 19A; New Members, 19A
Miscellaneous Short Items —
Louvers and Downlights in Conference Room, Chicago, Ill., 559; Office from Former Storeroom, Rochester, N. Y., 566
Illuminating Engineering Society — 4A
Sustaining Members — 20A
I.E.S. Publications — 33A
Index to Advertisers — 37A

1951-1952 Officers

S. G. Hibben — President
E. M. Strong — Vice-President
A. H. Manwaring — Vice-President
Clarence C. Keller — Gen.Sec'y
R. F. Hartenstein — Treasurer

Staff

Ruby Redford — Editor
Clayton E. Ellis — Advertising Manager

Publications Committee

E. C. Huerkamp, Chairman
J. M. Stedman
E. H. Church

STATEMENTS and opinions in articles and papers in ILLUMINATING ENGINEERING are the expressions of contributors and do not necessarily represent the policies or opinions of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council of the Illuminating Engineering Society.

Founded 1906

ILLUMINATING ENGINEERING SOCIETY

A. D. Hinckley
Executive Secretary

C. L. Crouch
Technical Director

PUBLICATION office 32d Street & Elm Avenue, Baltimore, Md.

EDITORIAL and advertising offices 1860 Broadway, New York 23, N. Y.

ILLUMINATING ENGINEERING: The Journal of the Illuminating Engineering Society. Copyright 1951 by the Illuminating Engineering Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. ¶ Subscription $10 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.50. ¶ Address changes must be received at I.E.S. headquarters by the first of the month to be effective with the issue of the next succeeding month.

WANTED: *ILLUMINATION EXPERTS...*

Hard Work — Long Hours — No Pay!

I.E.S. — the Illuminating Engineering Society — fills nearly a thousand such jobs every year!

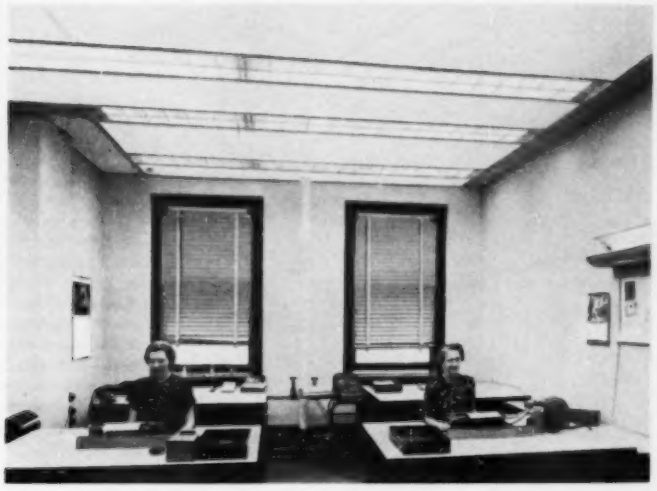
Members of I.E.S. committees, in meetings like this, combine their knowledge and experience to develop projects that will advance every phase of illumination technique. The results of their work are placed at the disposal of the entire lighting industry—help everyone who plans, makes or sells lighting equipment.

Borrowing time from their regular jobs, working for companies whose payrolls will never list their names, I.E.S. committee members make a major contribution to the welfare of their industry.

And to that of the public, also . . . as a glance at almost any home or factory or Main Street, on any evening, will prove. In the quality of the light, its efficiency and low cost, in the fixture design, are literally scores of ideas born at I.E.S. committee meetings —products of time and talent donated to the advancement of an entire industry, and to the benefit of the public it serves.

Illuminating Engineering Society

1860 Broadway, New York 23, New York



Troffers and Luminous Ceilings Go Well Together

By R. L. OETTING

TROFFERS and transmitting ceiling elements have been combined in a Nela Park office with very satisfactory results. Brightnesses in the general field of view are low but the "dark" ceiling effect of many conventional troffer installations has been avoided.

A relatively high level of illumination was desired but excellent appearance and comfort were also essential objectives. After three months of service, the average illumination is just over 100 footcandles. Favorable comments from employees, engineers and architects indicate that the other aspects of the design are also realized.

Two two-lamp anodized aluminum troffers have a semi-parabolic reflector over each lamp. Low surface brightness throughout the shielded zone led to the selection of this equipment. The ceiling elements are made luminous by light from lamps on top of the troffer channels. Using a common channel for all three lamps offers certain manufacturing and installation economies, but until manufacturers introduce the design as a standard, the

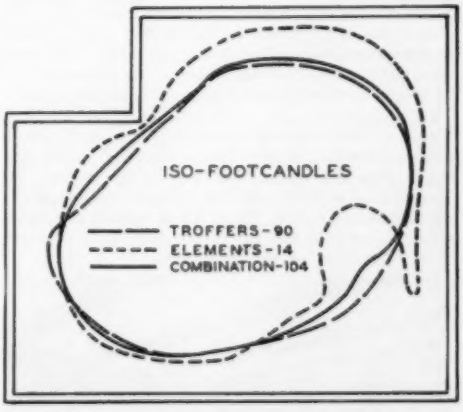


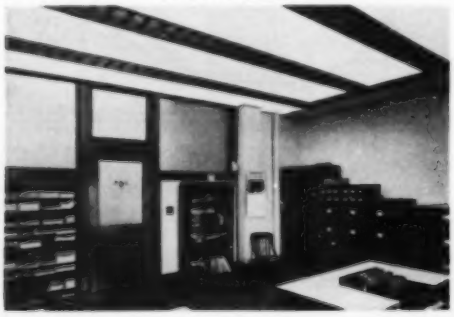
Figure 2. Iso-footcandle curves show the distribution of average illumination values from the troffers, the ceiling elements and the combination. The peculiar shape of the ceiling element curve in the lower right corner is caused by discoloration of the plastic where exposed to germicidal radiation. Use of louvered bactericidal units will reduce this effect.

Author: General Electric Co., Nela Park, Cleveland, Ohio.

Figure 3. The indicated brightness values in footlamberts were measured from camera position. Ceiling sections are not completely diffusing and values normal to them range from 36 to 63 footlamberts. Troffer brightnesses are shown for eight locations as minimum to maximum ranges. Brightness ratios between the work and the lighting system are excellent. Walls and desks now have recommended reflectances. A Van Dyke brown or white stipple finish is used on the walls. Desk tops are Armstrong 416 Mist Green. Interference of dark furnitnre and equipment finishes with the brightness pattern is obvious. The fluorescent lighting load is 2591 watts or 8.0 watts per square foot.

Figure 4. The troffers produce 90 footcandles or 86.5 per cent of the total horizontal illumination. The indicated coefficient of utilization of .38 is about 10 per cent lower than that published for these units. The difference may be due to a high ambient temperature at time of test.

Figure 5. The horizontal illumination from the luminous elements averages 12 footcandles. The finish on the ceiling is white and natural aluminum on the troffers. The coefficient of utilization for the elements is about .09 and .26 for the combination. The ratio of vertical to horizontal illumination is 0.65 for the elements alone, and 0.25 for the combination.

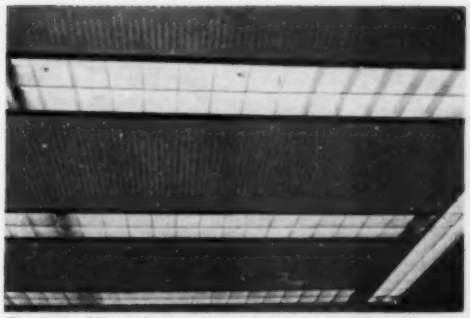


use of separate strip lighting is less expensive.

Ceiling-mounted strip lighting should also result in improved utilization. With lamps mounted on top of troffer channels, the ceiling elements are lighted indirectly. A large proportion of the lamp output is intercepted by the horizontal channel surfaces on which dust and dirt are likely to accumulate rather readily. On the other hand, the indirect-type of lighting has a distinct advantage if centers between troffers are great and uniform brightness of the ceiling elements is desired.

All but one of the materials in the Nela Park installation are handled by electrical contractors. The acoustic tile along two sides is the exception. It was used to simplify the treatment of these perimeter sections and to obtain information on the durability of gypsum-type tile when used without backing or edge splines. These tiles are laid on aluminum furring angles which are items in a fixture manufacturer's line of troffer accessories. The troffers, except for the addition of the third lamp, were a standard product of another manufacturer.

There is a very interesting possibility of applying flanges to the many semi-direct units on the market and using them rather than troffers. They provide the necessary upward light and the resulting brightness on sections spanning the space between units should be more uniform than that now obtained by direct reflection from the ceiling. The fact that few of these units have dimensions which are multiples of 12 inches is of little concern since fixture and spacing dimensions need not be coordinated with those of standard acoustic tile. This also suggests the opportunity of increasing the width of multi-lamp troffers to increase the efficiency and reduce the brightness. Narrower single-



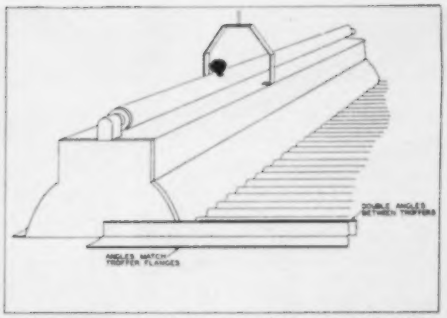
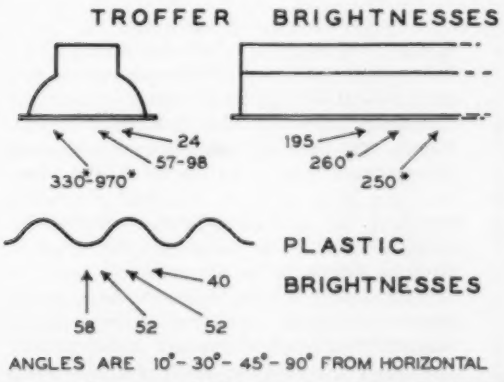


Figure 6. View of the ceiling obtained by tilting the camera upward at 45 degrees. The troffer shielding angle is slightly less, exposing lamps in the near unit. The reflectors "fill" with brightness, however, to provide a luminous backgrounds for the lamps. Within the shielded zone, the reflectors brightness drops rapidly as the viewing angle approaches the horizontal. These characteristics of the parabolic reflector recommend its greater use in lighting equipment for applications where comfortable seeing is important.

Figure 7. In most instances, spacing between troffers is maintained by aluminum angles fastened to the end plates of the troffers. Sections of angles are fitted between troffer flanges to conceal and to support the ends of the plastic sheeting. Figure shows how three rows of units terminate at a single troffer. The flanges on the ends of these rows overlap the side flange of the single unit. So few have noticed this detail that it cannot be objectionable.

lamp units would be practical and some savings, especially in the cost of aluminum troffers, might be effected while maintaining the excellent efficiency and brightness characteristics of these units.

Conventional troffers and modified suspended lighting equipment will combine effectively with luminous ceiling elements. Experience with the Nela Park installation indicates that the advantages of troffers and luminous ceilings have been retained while some of the disadvantages have been minimized. The sections between the troffers are brighter than they would be by reflected light alone. On the other hand, these sections are considerably less bright than would be a continuous luminous ceiling delivering 100 footcandles. The combination introduces pattern for variety and interest but is not distracting. Such combinations permit the concentration of light over specific areas in an obvious but not objectionably obtrusive way. There are many possibilities of using luminous elements and fixtures in effective combinations. They go well together.



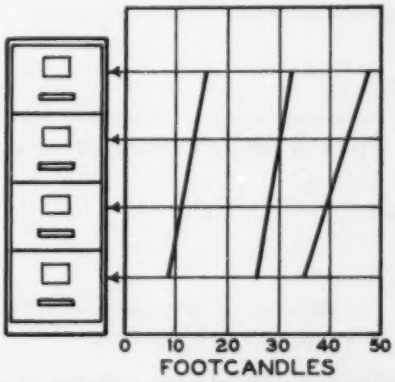


Figure 8. The average brightness at any given angle with the plane of the plastic was found to be the same whether measured with the corrugations or across them. Luminaire brightnesses are maximum values for surfaces of the units. Those with an asterisk (*) indicate that a portion of the lamp is exposed but not included in the reading. The ranges indicate a difference in brightness between the two reflectors with the brighter one being away from the point of observation in each case.

Figure 9. The distribution of vertical illumination is shown here for the front of the four drawer file which is the second from the left in Figure 3. Values were 20 per cent less on the end unit in the corner—four files to the right.

Every installation of quality lighting is, in effect, a stepping-stone to more improvement. The lighting objective in the design of the older installation in this office, photo at left above, was comfort. The system was "luminous" but presented a very low order of brightness in the direction of view. The indirect aspect of the lighting minimized reflected glare. The present installation, at right, is contemporary, not only in the lighting elements but also in the use of lighter room surfaces, with better brightness reflectances.

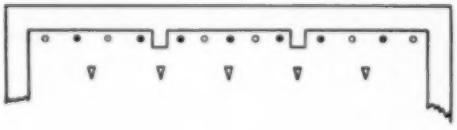


Figure 3. A schematic layout of the 96T12 lamps and acoustic wedges. The utilization for circuit A is 0.36; for both circuits is 0.35. The apparently lower utilization for the 14-lamp circuit is due in part to the interference of the beams. Another factor is the increased ambient temperature due to the higher wattage loading of the combination. Both are real factors not readily reflected in theoretical calculations.

Engineering for Lighting Comfort

THESE illustrations of another office at Nela Park offer an opportunity for several comparisons. The older installation offered a means of controlling the brightness of filament indirect lighting. The parabolic- etched-aluminum elements reflected little light in the normal viewing directions and were, therefore, considerably lower in brightness than conventional diffusely-finished flat ceiling surfaces. This system and the results it produced helped to develop present concepts of lighting comfort and the design of many types of luminaires. The new installation is a contemporary example of one means of achieving quality lighting. It employs fluorescent lamps above plastic panels and high reflectance finishes for major surfaces throughout the room. Acoustic treatment is combined with the lighting system. The wedge-shaped members attached to the supports for the plastic panels contain sound absorbing material. Color, which is missing in the illustrations, has been used

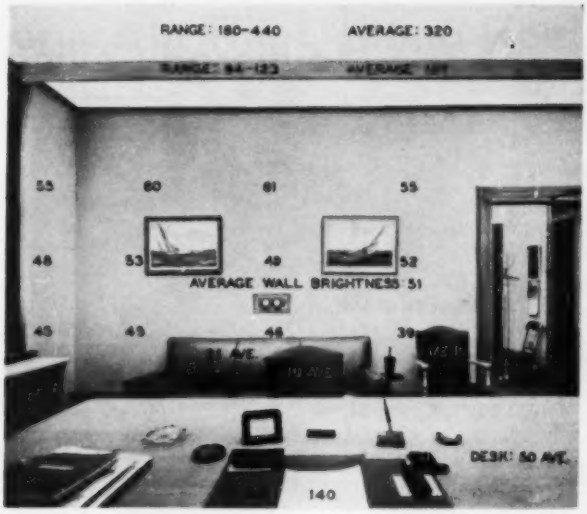


Figure 4. Brightness measurements taken by an observer seated at the table. Window walls are a warm gray having a reflectance of 0.58. The inside walls are a grayed green of 0.49 reflectance. With daylight on them, these green walls become about as bright as the gray ones with the higher reflectance. The color difference adds a change of pace and a note of interest to the room, not to be found in a photograph.

carefully yet extensively. Window walls are a warm gray and inside walls a grayed green; with daylight on them, these green walls appear about as bright as the gray ones. This color difference adds a note of interest.

The plastic is a relatively new acrylic formulation which has a fire rating of "self-extinguishing." The light transmission is over 55 per cent initially and it is expected that this plastic will have the permanency of transmission of other acrylic materials. The transmission is spectrally non-selective. The plastic is but moderately diffusing which helps account for a considerable spread from average among the individual brightness measurements. The resultant illumination, however, is well diffused since fluorescent lamps are used and the reflectance of ceiling, walls and furnishings are high.

Brightness measurements (see Figure 4) were taken by an observer seated at the table. This office is not large enough to realize appreciable louvering effect from the acoustic wedges. But brightness measurements indicate how valuable they become in larger areas. The effective ceiling brightness for direct view is reduced from that of the plastic to values equal to or less than that of the work. In a wide room a grid of these wedges at right angles to each other would provide further visual improvement. Since this pattern may introduce more acoustical treatment than required, it suggests that elements in one direction might carry conditioned air instead of sound-absorbing material. Although luminous ceiling minimize the annoyance of reflected glare, the highlights in the sheen of the chair upholstery in this illustration suggest that this type of problem may still be present where shiny surfaces are involved.

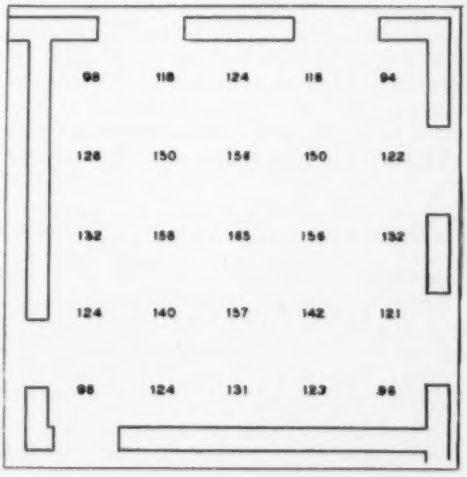


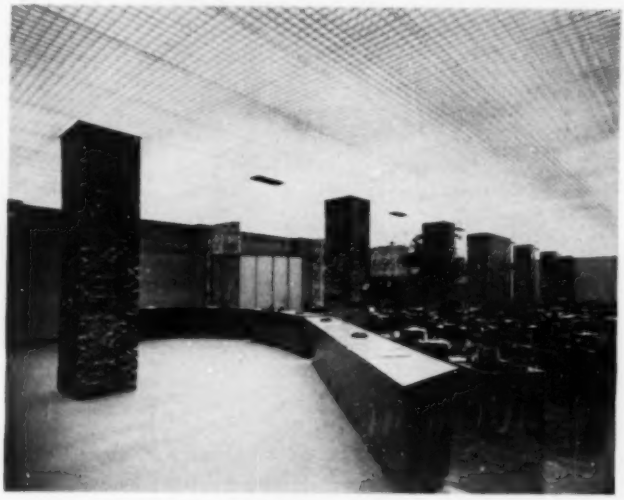
Figure 5. This plot shows the distribution of illumination. The average was 131 footcandles after two months of use.

Louvered-Ceiling Office

LIGHTING OBJECTIVE: To illuminate an insurance office by means of a louverall ceiling.

Installation at the National Automobile and Casualty Insurance Company, 639 South Spring Street, Los Angeles;

architect: Stiles Clements.



General Information: The 150 x 50 x 22 foot area shown here is decorated as follows:

Walls		
south (shown in photo)	red-brown	50% RF
north	cream	60% RF
Floor		
composition tile	mottled green	20% RF
carpet	green	21% RF
Area above louvers	white	80% RF
Columns	mottled green (simulated marble)	25% RF
Counter	maple	30% RF
Desks		
tops	black*	4% RF*
sides	olive green*	10% RF*

Installation: Continuous rows of 200 ma 96-inch T-8 4500K fluorescent lamps with high power factor Sola ballasts are mounted 21 inches apart 22 inches above .032-inch aluminum louvers (painted white). The louver cells are 4 inches square and 4 inches deep, and mounted in 4-foot square sections 14 feet above the floor.

*NOTE: The dark desks do not meet the recommendations of the *I.E.S. Recommended Practice of Office Lighting.*

Average illumination level after 100 hours operation was 63 footeandles. Brightnesses are as follows:

Louvers		
45°	62	footlamberts
30°	45	footlamberts
Walls (5 feet below louvers)	8	footlamberts
Floor		
composition	8	footlamberts
carpet	10	footlamberts
Columns (5 feet below louvers)	5	footlamberts
Counter		
top	14	footlamberts
sides	4	footlamberts
Desks		
tops	2	footlamberts
sides	1.5	footlamberts

Lighting equipment is manufactured by the Carr Company, Oakland, California, supplied by Black and Lem Engineered Lighting and installed by Newberry Electric Corp., both of Los Angeles.

Lighting data submitted by Department of Water and Power, City of Los Angeles as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society
1860 Broadway, New York 23, N. Y.

Series XVI 11-51

A.I.A. File No. 31

Public Buildings Service In The Lighting Field

By THOMAS F. COGHLAN

THERE may be many in the various branches of the lighting industry who do not have a clear picture of the functions and responsibilities to the taxpayers of the Public Buildings Service. Some may also have wondered why we have assumed such a definite position in designing as well as purchasing lighting equipment.

There may be some few persons, who for one reason or another, resent the fact that we have insisted upon filling a role other than that of just buying lighting fixtures. I believe, however, that with an explanation of our overall operation, you will agree that any consumer, whether a private concern or a Government Agency, who must purchase lighting equipment in the quantities that are used by the Public Buildings Service, should carefully study and plan their own needs, and if necessary to better meet their requirements, they should develop their own designs based on their particular requirements if commercially available equipment is not suitable.

My remarks are not going to be of a technical nature, but rather a simple explanation of our activities in your field.

Many of you in the sales end of the industry have probably heard me explain our methods and aims before. To those of you who may not be familiar with our functions, I want to tell you we have a very logical place in this business of illuminating engineering. I also want to tell you some of the planning behind the preparation of the "Illumination Chapter" of the Public Buildings Service's Mechanical and Electrical Engineering Manual and why we have found it necessary to develop our own line of standard lighting fixtures.

Our planning is based on years of experience in designing and operating Federal buildings and a sincere effort to obtain lighting equipment that is most suitable for the Government's needs. In order to take advantage of the broadest possible experience, we solicited suggestions and criticisms from employees throughout our Regional Offices as well as from the operating employees in the individual buildings. We naturally received a lot of suggestions that had no value — but we also received many that had merit and have been included in our plans.

Our Director of Design and Construction has been most cooperative in our planning of better lighting in Federal buildings. He insists that every suggestion be fully explored for merit and possibilities. He has a deep interest in the illumination branch of our work and appreciates the fact that other features of the building, such as color and finishes, are just as important a part of the lighting system as the lighting fixture itself. He fully recognizes the importance of the illuminating engineer in producing livable buildings and that people perform their best work under improved lighting conditions.

At the end of World War II, we prepared a manual covering all branches of engineering involved in the various types of buildings that are usually designed and constructed by the Public Buildings Service. This manual contains a chapter on illumination in which we attempted to cover the lighting requirements for areas most common to the different types of buildings for which we are responsible.

About that same time, the Illuminating Engineering Society was also developing a handbook. I had hoped that the I.E.S. Handbook would be such a complete and practical publication, that, except for some of our special requirements, we could make unqualified references to it in our manual. That would not only have saved us a lot of work, but would also have added prestige to the I.E.S. Handbook.

I am sorry to say that, in my opinion, the first edition of the I.E.S. Handbook has fallen far short of the goal that many of us had set for it. I mention this in the spirit of constructive criticism because I know many other members who are as disappointed in this first edition as I am — and when revisions are written, I would still like to see it developed into a useful instrument that could be placed in the hands of the engineer on the board, and give him sufficient practical information and definite recommendations as to type of lighting equipment, to guide him in planning the most satisfactory lighting layout for various areas and tasks.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Author: Electrical Engineer, General Services Administration, Washington, D. C.

I suggest that a technical handbook of this sort should be prepared by engineers more interested in illuminating engineering than in just selling lighting fixtures. I am sure that would produce a much more useful handbook. It may also be a guide to manufacturers and result in the production of better engineered lighting fixtures.

I trust that you will forgive me for taking advantage of your hospitality and making these seemingly unkind remarks — but they are facts and I have heard them whispered by many and I think they should be said out in the open where some good may come of them.

Now to get back to my subject and the "Illumination Chapter" of the Public Buildings Service manual. I do not claim that our manual is the last word by any means — it has been in print four or five years now and we all know that with new lamps being added to our available light sources and with new techniques being developed, amendments are in order. It was written with the idea of issuing amendments as they are needed.

It is our aim to see that the illumination of Federal buildings will be as adequate and modern as it is practical to make it. We do not intend to lag behind the private engineer in taking advantage of new worthwhile developments — neither do we propose to spend the taxpayers' money on new untried gadgets or ideas that are questionable or impractical from the Government's standpoint.

Our Director of Design and Construction insists that our buildings be functional in every respect and we intend to see that the illumination fully complies with that requirement. The days of installing lighting fixtures just to be looked at and admired as architectural features are gone.

We propose to eliminate the monstrous exterior lighting standards and lanterns that have adorned so many public buildings. They are usually worth little as sources of light.

Exterior lighting equipment will be built into soffits or walls and be as inconspicuous as possible — fitting into the architectural treatment. It will be designed to direct the light to the areas where it is needed with the least possible glare.

Our manual discourages the planning of floodlighting of Federal buildings except in cases of monumental projects — and then only after careful study, because we know from past experience that even where floodlighting equipment has been installed, it is seldom, if ever, permitted to be operated for reasons of economy.

Lobbies and other public spaces that are usually given special treatment may be lighted by various schemes. There may be cove lighting, recessed troffers — louvered or glazed, or even luminous or louvered ceilings, depending upon the requirements of the space, or some other method to obtain the results desired by the architect — and naturally it is the engineer's responsibility to see that the requirements of good lighting as well as the architect's desires are complied with. Incandescent as well as fluorescent light sources will be utilized as best suited to the particular conditions.

Generally our office areas and drafting rooms will be illuminated by luminous indirect fluorescent lighting equipment — except of course, in cases where of necessity the finishes, ceiling height or some other conditions may prevent us from providing the ideal and require a compromise.

The decision to standardize on the luminous indirect system of lighting was based on studies made in our own offices and constant observation of successful installations and trends in privately designed commercial buildings.

This system has proven to be more comfortable because of its ability to produce adequate intensities with a minimum of both direct and reflected glare.

This system also permits complete utilization of every square foot of the space and makes possible the placement of desks and other equipment without regard to the locations of the overhead lighting equipment. It has also resulted in the elimination of the need for local desk lamps.

We realize that a luminous indirect system of lighting requires that we not only provide *but maintain* a white ceiling with a reflectance of 70 per cent or better, because the ceiling becomes an important part of the lighting system.

With proper spacing of fixtures and suitable suspension from the ceiling, brightness ratios far better than those recommended by the Illuminating Engineering Society are obtained. This assures more comfortable seeing conditions because mental and physical fatigue is minimized.

An interesting and unusual characteristic appears to be inherent in this luminous indirect type of lighting system — as dust accumulates on the lighting equipment and on the ceiling, the comparative brightness ratios tend to draw closer together and improve even though the quantity of light is naturally reduced by the depreciation of the lamps and the accumulation of dirt.

I do not want to leave the impression that I am recommending that dirt be encouraged to accumulate and remain but I do want to point out that the very important matter of comparative brightness—

the feature or characteristic that determines whether a lighting system will be comfortable or not — changes only slightly during this natural depreciation period.

Our lighting problems involve many types of work other than purely office tasks. Post Office workrooms, for instance, require much of our attention. We have found that the louvered bottom, open top type of fluorescent lighting fixture, designed within certain requirements, is quite satisfactory for moving tasks such as those performed in Post Office workrooms. Accordingly, our manual recommends this type of lighting for workrooms and similar areas.

Now I would like to tell you a little about the development of our standard line of lighting fixtures — but first I want you to know that there are several important considerations that have convinced us that we should design our own fixtures, accepting no alternates or substitutes.

Years ago, we found that by that policy only could we obtain real competitive bids, with all bidders and manufacturers placed on the same basis.

We have also found that we can obtain better lighting fixtures for the Government — superior to the usual commercially stocked fixtures.

And then there is the very important advantage of being able to remodel and extend our existing lighting systems — in fact we can join new fixtures directly to existing equipment, and regardless of who makes them, they fit and match because they are all made from the same details. We can make repairs to existing equipment, buying end plates or any other parts by real competitive bids and we know they will fit. We don't have to "frame up" a specification with the idea of trying to get the same manufacturer who made the original fixtures — and hoping that he has not changed his line, so they will not match the original ones, or that he has not discontinued that item.

Another desirable advantage lies in the fact that when planning a new building we know the necessary dimensions, etc., to completely design the layout, without having to wonder who might get the job and allow for possible variations due to the widely varying details and dimensions of the different commercial fixtures that may possibly be installed under any other competitive method of obtaining fixtures.

But — aside from these very important advantages, this policy of standardizing on our own designs is definitely in your interest as taxpayers — and after all it is our responsibility in Public Buildings Service to represent the taxpayers' interests.

In designing our standard line of fixtures we have placed utmost importance on several points— they must be substantial — maintenance operations must be simple, practical and as convenient as possible—they must eliminate dust-collecting contours and decorations so far as possible — they must be designed so that accessories, that are subject to possible replacements, may be replaced with the least possible dismantling of the remainder of the equipment. In order to minimize the necessity for these annoying repairs we require that ballasts, lampholders and other accessories be of highest quality commercially available.

Our responsibility does not end when the fixtures we have designed and purchased are installed, because the Buildings Management Division of Public Buildings Service then takes over and maintains and operates them. So you see we have to live with what we design and by constant cooperation with our Management Division we are kept advised of difficulties that may show up in maintenance and operation of the equipment, so that we may make whatever changes in our designs that may be necessary to see that they don't recur on future projects.

In order to meet our most urgent needs, the first standard fixture to be developed was the luminous indirect fluorescent fixture for two 40-watt, T-12 lamps, that, as many of you know, is the Public Buildings Service's type No. 355.

While working out substantial and simplified mechanical details, we were also investigating the various characteristics of different types of plastics. We decided that methyl methacrylate would be the most suitable plastic — and although perhaps not the cheapest material in first cost, we expect it will prove to be the most economical in the course of time. I think our decision is pretty well supported by the fact that this particular type of plastic is also being recognized by commercial illumination engineers when designing lighting installations that are not dictated by first cost alone.

Realizing the importance of brightness ratios, in creating satisfactory seeing conditions, made the matter of surface brightness a very serious detail. We decided that the brightness of the reflector should not be more than 150 footlamberts nor less than 100 footlamberts. This determination was made through the simple method of observation, together with a few basic principles, not by trying to make a complex and highly technical problem of it — because as a matter-of-fact the things that tell whether a lighting system is satisfactory are

living under it and observing it — and to be satisfactory it must be comfortable. If it is not comfortable and satisfactory, you do not need to be told—your eyes and your nervous system will soon let you know.

Thinking of our maintenance men, we have made their work easier by designing the reflectors so that they can be easily removed from the supporting webs by sort of a rotary, lifting motion — no screws or fasteners requiring pliers or screwdrivers.

In the order of our needs, the next fixture to be developed was the type having luminous sides, louvered bottom and open top — known as Public Buildings Service Types Nos. 362 and 363, designed for use with two 40-watt, T-12 fluorescent lamps per basic unit and Public Buildings Service Types Nos. 364 and 365 for use with four 40-watt, T-12 fluorescent lamps. This particular type has been used in the workrooms of our Post Office projects as well as in many office areas where conditions make the use of the luminous indirect type No. 355 impractical. Types 362 and 364 are provided with a suspension stem at each end, while the types 363 and 365 are designed with a twin stem suspension for installation from an outlet located over center of the fixture.

Still thinking of the maintenance man, we designed the louver assembly so that it can easily be hinged downward from either side for relamping or just as easily completely removed for cleaning. Since our original design we have revised the method of fastening the luminous side panels so that they also can be easily snapped on or removed for cleaning — without screws or fasteners requiring pliers or screwdriver. This change means a considerable saving of costly installation time as well as making the maintenance man's job simpler and also less costly.

We have also designed a totally indirect fluorescent type of fixture quite similar in appearance to the luminous indirect type 355, except that the outer body is satin-finished aluminum instead of luminous plastic.

In addition to suspended types of fluorescent fixtures we naturally have need of recessed fixtures where ceiling heights may be limited or where architetural desires may be the governing factor. Because of excessive brightness ratios, however, as well as other undesirable characteristics we would not normally plan office lighting by this type of equipment. However, there are many locations where these unwanted features are not too important — in fact contrasts are sometimes planned for effect.

From the standpoint of appearance I would like to recommend the recessed louvered bottom equipment for office illumination, but unfortunately I can find only its appearance in its favor. Aside from the higher cost of such an installation, undesirable brightness ratios as well as direct and reflected glare greatly outweigh the matter of appearance when determining the requirements of satisfactory office illumination.

In an effort to promote safety by providing better lighting of stairways and escalators we have modified the cross louvers of our louvered bottom recessed fluorescent fixtures so they will be in the vertical plane when this fixture is located in the sloping ceiling over stairs and similar locations. This results in excellent illumination downward to stairs and provides adequate shielding of the bare lamps to people in the downward direction. Many of you have probably seen this fixture in use at Washington National Airport and in the new General Accounting Office Building.

In line with our desire to standardize we have made stem spacings and basic unit lengths of all suspended types, conform with the nominal lengths of the various lamps — the only exception being at ends of single fixtures or multiple fixtures where the stem moves in ¾" from end. The overall lengths of the housings of our recessed types conform with the various nominal lamp lengths plus ⅛" while the widths of housings have been set to fit in with standard ceiling tile dimensions.

Having these dimensions definitely fixed is a big help to the engineer when planning a layout — he can plan outlet and stem locations and place recessed housings with a considerable degree of accuracy and not have to wonder which one of many dimensionally different commercially available stock fixtures may be installed on the job.

Although the progress of our program has been somewhat disrupted since World War II we have installed our standard fixtures in sufficient quantities to convince us that our policy is right and definitely in the Government's interest — and if it is in the Government's interest, it is also in your interest as taxpayers.

One large project that has recently attracted considerable attention is the new General Accounting Office here in Washington. Although the G.A.O. Building was actually commenced before World War II, it has turned out to be one of our first post-war buildings because the construction was abandoned during the war.

That change in the original construction schedule will prove to be fortunate for the eyes of the em-

ployees who will be assigned to that building because it has resulted in the planning of a more adequate system of illumination than would have been done in the early Forties. The additional time permitted the development of standard designs that will not only provide efficient comfortable illumination but will result in more economical and easier servicing.

In addition to many incandescent lamps, over 50 miles of fluorescent lamps are installed in fixtures and coves in this building.

Although the plans for the General Accounting Office indicate a block type of building with large open office areas, the lighting layout as well as air diffusers and other services were planned so that partitions can be erected on the columns or so that bays can be quartered or halved with the least possible interference. We had to anticipate the possibility that partitions may be wanted at most any location and require the least possible alterations to the building.

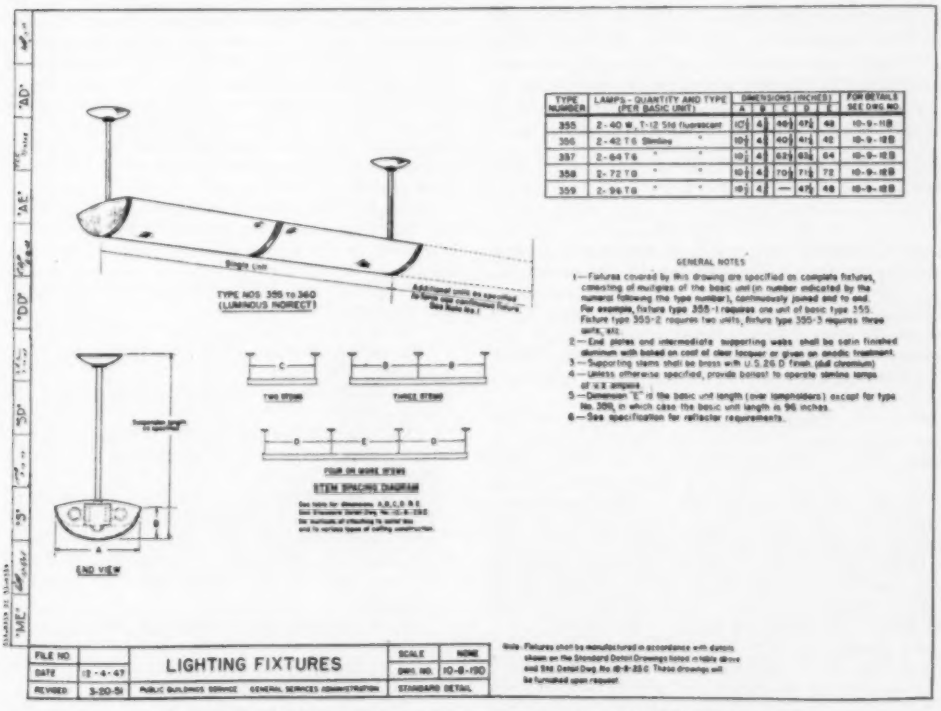
This important requirement has been met, by providing a wiring layout which in conjunction with our standard lighting fixture type 355 permits the removal of any 4-foot basic unit without disrupting the other units or the switching arrangement.

The typical bays are 25 feet square and are provided with four No. 355-5 luminous indirect fixtures symmetrically spaced on 6'-3" centers. A survey of the office areas showed brightness ratios of less than 2 to 1 between the luminous body of the fixture and the brightest and darkest ceiling areas above and between the luminaires.

Before occupancy there was an intensity of 55 to 58 footcandles at desk height, which reduced to approximately 42 footcandles when the furniture and miscellaneous equipment were moved in. With reasonable maintenance we expect to meet the 30 footcandle in-service level that we designed for general office areas.

The elevator lobbies and corridors on the main floor are adequately lighted by cove lighting — utilizing slimline lamps. You will also see entrance lobbies and corridors well lighted with recessed fluorescent units — some with louvers — some with diffusing glass panels.

Combining the desires of the architect and the


TYPE NOS. 355 to 360
(LUMINOUS INDIRECT)
Single Unit
Additional units as specified
TWO STEMS
THREE STEMS
FOUR OR MORE STEMS
STEM SPACING DIAGRAM
END VIEW
GENERAL NOTES
1 — Fixtures covered by this drawing are specified as complete fixtures, consisting of multiples of the basic unit (in number indicated by the numeral following the type number), continuously joined end to end. For example, fixture type 355-1 requires one unit of basic type 355. Fixture type 355-2 requires two units, fixture type 355-3 requires three units, etc.
2 — End plates and intermediate supporting webs shall be satin finished aluminum with baked on coat of clear lacquer or given an anodic treatment.
3 — Supporting stems shall be brass with U.S.26 D finish (dull chromium)
4 — Unless otherwise specified, provide ballast to operate slimline lamps at 430 amperes
5 — Dimension "E" of the basic unit length (over lampholders) except for type No. 360, in which case the basic unit length is 96 inches.
6 — See specification for reflector requirements.
LIGHTING FIXTURES
FILE NO.
DATE 12-4-47
REVISED 3-20-51
PUBLIC BUILDINGS SERVICE GENERAL SERVICES ADMINISTRATION
SCALE NONE
DWG. NO. 10-B-150
STANDARD DETAIL

TYPE NUMBER	LAMPS - QUANTITY AND TYPE (PER BASIC UNIT)	DIMENSIONS (INCHES) A	B	C	D	E	FOR DETAILS SEE DWG NO
355	2 - 40 W. T-12 Std fluorescent	10½	4½	40½	47½	48	10-B-118
356	2 - 42 T6 Slimline "	10½	4½	40½	41½	42	10-B-128
357	2 - 64 T6 " "	10½	4½	62½	63½	64	10-B-128
358	2 - 72 T8 " "	10½	4½	70½	71½	72	10-B-128
359	2 - 96 T8 " "	10½	4½	—	47½	48	10-B-128

Note: Fixtures shall be manufactured in accordance with details shown on the Standard Detail Drawings listed in table above and Std. Detail Dwg. No. 10-B-250. These drawings will be furnished upon request.

An example of the specification size sheets for the standard lighting fixtures.

requirements of the illuminating engineer we have lighted the cafeteria with recessed fluorescent units equipped with diffusing glass covers and utilizing deluxe or soft white lamps.

We also have some specially designed lighting equipment in addition to our standard fixtures. The Comptroller General's office, for example, is comfortable lighted by totally indirect suspended troughs that fit the room geometrically and architecturally.

Escalator traffic is well lighted by recessed fluorescent units equipped with louvers so arranged that traffic in the downward direction is well shielded from glare and light is directed onto the treads.

There are many other lighting features in this project; you will find adequate and efficient illumination from the penthouses right down to the parking areas, transformer vaults and industrial areas in the basement and sub-basement. I believe this building, as well as many others we have produced, offers sufficient evidence as to why we are in every phase of the field of illuminating engineering except the actual manufacture and installation of the equipment.

The illustration shows an example of the specification sheets for our standard lighting fixtures. In addition to the notes and details shown on these specification size drawings, we furnish full size details covering the manufacture of these fixtures. And, as I have said before, in order to keep all bidders on the same basis, we require strict compliance with every detail and will accept no substitutions or alternate equipment.

DISCUSSION

C. T. Bakeman*: I believe papers of this kind by people with this type of experience, background and position are invaluable in their stimulation to our Society and should certainly be encouraged. The fact that the United States government must design its own fixtures in order to adequately serve lighting needs and assure competitive bidding certainly should be a stimulant to the industry members of the Society.

Of greater impact to the Society itself is the fact that such a large user, in fact the largest user of lighting in the world, finds the standards published by the Society inadequate to its quality needs. This indictment by only one large user, even the largest, might be subject to discount; however, we find an increasingly large segment of users finding our standards similarly ineffective. These users guided by their own dearly paid for experience based on the very casual brightness limitations which are so inadequately covered and lightly passed over in our Handbook are losing confidence in the status and stature of the Society.

For example, we find the National Council of Schoolhouse Construction having to disregard the school lighting standards sponsored by the Society and prepare their own with adequate brightness coverage. For example, we find surveys of office lighting users showing a high degree of complaint and dissatisfaction with their excessive "glare" (brightness ratios) that are permitted, yes, even fostered, in our office lighting standards of the Handbook.

The inevitable result of this failure of the Society to keep pace with the progress in quality standards is loss of prestige and effectiveness in this field where it should be in undisputed position of leadership.

I am most heartily in agreement with the major concepts presented by Mr. Coghlan and hope that this paper will be carefully read and seriously considered by those in the Society primarily responsible for the Society's present position and future progress. I'm sincerely hopeful that its impact will stimulate prompt action even if this involves a reorganization or a change in the composition of our initiating and governing committees. If we do not meet this challenge, our position as an engineering society is forfeit and we become relegated to the status of commercially expedient usefulness.

Willard C. Brown*: I would like to compliment Mr. Coghlan on his constructive efforts . . . and his fine results . . . in improving the lighting of the new government buildings.

Perhaps some people have felt that those in Mr. Coghlan's group had committed themselves *exclusively* to the use of luminous indirect lighting. This paper should help to dispel such misconception. On the other hand, there isn't much doubt as to the author's opinion of other systems for general office use. In our own experience, other types (including the extreme of direct-lighting troffers) do not necessarily lead to "excessive brightness ratios . . . direct and reflected glare . . . and other undesirable characteristics." Indeed, we have found that with suitable care in the design installation and use, one can achieve quite acceptable lighting results with other kinds of systems . . . and often at less cost. Of course, I did say *with proper care*, to avoid the faults Mr. Coghlan mentions. But proper care is necessary with any lighting system if best results are to be obtained.

The author comments that with reasonable maintenance they expect to maintain an illumination level of about 30 footcandles in the general accounting office. I hope that the government will not have the same difficulties in actually getting adequate maintenance that have plagued private operation.

A few questions to the author:

Do you rspecifications now include T-12 slimline lamps for the indirect unit?

Has consideration been given to the use of the 5-foot 85-watt lamp?

Have you given out any data as to the actual cost per unit to the government, of these luminaires built to these high-quality standards?

In the light of Mr. Endres' comments (see article beginning p. 577) that at least 50 footcandles are desirable (really required) for operations such as card-punching, what provisions will be made in the future for providing more than 50 footcandles in government buildings?

On the matter of color of fluorescent lamps, the author mentions the use of deluxe lamps in cafeterias. Does he have any expressions of opinion as to preference of fluorescent lamp colors for general office work?

*Electrical Lighting & Industrial Equipment, San Francisco, California.

*Manager, Engineering, Lamp Division, General Electric Co., Nela Park, Cleveland.

GEORGE P. WAKEFIELD*: This is a most interesting paper and I believe it will have more reader interest than many a report recently published in the I.E.S. Two of its outstanding characteristics are frankness and positiveness. This is a far cry from usual Washington reports. Probably we can assume the author would make a poor politician! As I gather from reading the report and in conversation with Mr. Coghlan, one of the purposes of this paper is to ignite the fuse of action in Illuminating Engineers and sail them off to the Planet of Idealism. Where is this place? What is the Bowdwitch? Obviously, the I.E.S. Lighting Handbook should be the authority to recommend conditions for illumination. The Handbook is composed of recommendations for offices, schools, industry, etc. These recommendations are suitable for American Standard Association acceptance, hence for general use. A standard of this nature can never produce the exact course to Idealism but it will take you close enough so you can easily attain your objective.

Mr. Coghlan should realize and I am sure he does, that we have come a long, long way in improving Illuminating Engineering concepts. This has been done by honest, conscientious and factual members of the Illuminating Engineering Society and not by "engineers interested in just selling lighting fixtures."

It has been my observation in dealing with various committee functions on lighting recommendations that we have at times run out of basic facts suitable for new recommendations. These deficiencies have been remedied and are to fill in the gaps of which Mr. Coghlan complains. Speaking specifically about office lighting, it is our hope that a new recommended practice will provide comfortable seeing conditions for 90% of the workers. Now then, here is a specific instance of scientific data being used as basic specification material. I might also add, present illumination recommendations are much too complex and exact to be left to "your eyes and nervous system." In other words, we are at the stage in illuminating engineering of altering course slightly this way or that and then only if the scientific data are generally acceptable. Rule of thumb navigation is out.

This paper has been a "prod in the back" for all of us. May I suggest that a critical paper be read at least once a year within the Society?

BRUCE TODD**: The author is to be complimented on the thorough and intelligent approach to the problem of office lighting. Essentially all office lighting requirements, whether government or private, follow the same basis for design: namely, consideration of the general elements of quality and quantity of the light source and consideration of the practical factors of cost and maintenance. All systems are therefore a compromise of these factors and the problem is one of finding the best performance for the least owning and operating cost. On this basis it has been the experience of the cold cathode industry that a low brightness, long life source is well suited for office lighting applications. I should like to know what consideration has been given to the use of cold cathode light sources for office lighting in the public buildings service program.

THOMAS F. COGHLAN†: In reply to Mr. Brown's comments and questions I would like to know to what "other kinds of systems," "often *at less cost*" he refers, with which "quite acceptable lighting results" can be achieved. One must remember that with a troffer installation there is considerable construction work involved besides the actual troffer cost which my experience has shown makes a troffer installation of most any description more costly than a suspended fixture installation. Then there is the important matter of flexibility which must be considered in Federal buildings where partition changes must be anticipated and the ability to remove basic units or easily relocate entire fixtures or sections is an awfully valuable feature. This can readily be done by an electrician with any P.B.S. suspended fixture, such as types 355, 362, and others, whereas to make similar changes to a troffer system is a major operation involving not only the electrician but a plasterer and probably a lather as well.

I consider the luminous indirect system, which is accomplished by suspended fixtures, the poor man's luminous ceiling. If there are other systems offering illumination of equal quality and incorporating the flexibility required by P.B.S. at *less cost*, and which can be obtained by open competitive bids with all bidders on the same basis, we are interested in learning the details.

As Mr. Brown says, P.B.S. is not committed exclusively to luminous indirect lighting. There are times when quality must be compromised because of ceiling heights, finishes or some other condition where a more adaptable system must be used.

In answer to Mr. Brown's first question: P.B.S. fixture type No. 359, which is a luminous indirect unit, was designed originally for the 96-inch T-8, but will accommodate the T-12 lamp as well.

To the second question: Development of a luminous indirect for use with two 85-watt T-17 fluorescent lamps was commenced some time ago, but pressure of work and shortage of help has delayed its completion in spite of the fact that we have a need for it.

To the third question: Under a term contract ending June 30, 1951, P.B.S. purchased type No. 355-1 fixtures for $19.95, with additional basic units costing $16.75 each. Type No. 362-1 cost $20.50, with additional basic units costing $17.75 each. Type No. 364-1 cost $28.70 with additional basic units costing $26.25 each. These were the low bidders' unit prices which were obtained by open competitive bidding and covered complete swivel hanger for 30-inch overall suspension.

In answer to the fourth question, the Mechanical and Electrical Engineering Manual of the Public Building Service, issued in 1946, already requires that a minimum of 50 footcandles be provided for drafting, card punching and similar tasks. The minimum of 25 footcandles required by the P.B.S. Manual is for ordinary office tasks.

As for lamp colors, the 4500K lamp in conjunction with our standard office colors seems to provide an acceptable atmosphere for general office work.

With reference to Mr. George Wakefield's comments, he is correct in his assumption that I hope to "ignite the fuse of action." I sincerely hope that my remarks concerning the I.E.S. Lighting Handbook will play some part in developing a more useful publication. The number of members who went out of their way to express agreement with my remarks leaves me no doubt in the fact that there are many other members just as disappointed as I am in the present handbook.

I am often reminded of the statement made several years ago by Sam Williams to the effect that "many a good light-

---

*F. W. Wakefield Brass Co., Vermilion, Ohio.
**Swedish Iron and Steel Co., Westfield, N. J.
†Author.

ing job has been sacrificed on the altar of commerce." Regardless of how "honest," "conscientious" and "factual" members may be, the income of most of them depends upon selling what their employer makes and very few willingly reduce their incomes for the sake of science. As Mr. Wakefield knows, I had my name removed from the committee assigned to revising the "office lighting" section of the Handbook when I realized my efforts to correct some of my criticisms were futile.

I did not say that *illumination recommendations* should be left to "your eyes and nervous system," as Mr. Wakefield's comments imply. Referring to my paper it will seem that after I mentioned how simply we determined the brightness of our reflector I made the very obvious and perhaps unnecessary statement, "If it is not comfortable and satisfactory you do not need to be told—your eyes and your nervous system will soon let you know."

I would also like to repeat that I think many determinations can be made satisfactorily through practical common sense observations and trial rather than making them into complex and highly technical problems. Naturally certain basic principles must be observed and experience is necessary in arriving at accurate conclusions.

To explain further my feelings I would like to repeat several statements that I recently observed in a letter written by one of our West Coast members. He commented as follows:

> "The better informed eye specialists may one day suddenly realize what makes for quality office lighting conditions. They won't be able to find such a recommended guide in the standard tables of our I.E.S. Handbook. What then?
>
> "Suppose they decide to make their own standards, pointing the finger of suspicion at us as a group who willingly permitted the playing down of top quality recommendations in favor of the playing up of conditions which many of us know through experience definitely cause customer complaints of eye fatigue."

He further stated:

> "It seems to me that our present method smacks of setting up purely laboratory formulae based largely on partly proven facts plus competitive cost reasons in hopes that reactions from the 'patient' will not be too unfavorable."

A further statement suggests:

> "Before a similar move might commence in our field with the attendant loss of face and prestige, wouldn't it be better for us to set our house in order of our own accord."

I won't take more space repeating someone else's words but I think they express what a great many of us are thinking and if bringing these thoughts out into the light will "ignite the fuse of action" and result in recommendations of quality, my efforts will not have been wasted.

In reply to the question of the Fluorescent Lighting Association, the development of the cold cathode light source has been studied for its suitability as a light source in the Public Building Service's standard fluorescent lighting fixtures and will be used wherever it may be found adaptable to P.B.S. requirements.

A Method of Calculating Direct Illumination from Linear Sources

Additional Discussion and Rebuttal on paper by R. G. McPhail

(Published October ILLUMINATING ENGINEERING, pp. 511-520)

JOHN A. LOSH*: We know quantitatively that the candlepower of a light source decreases when the distance to the measuring plane is less than five times the maximum source dimension. Mr. McPhail derives data where the inverse-square law is valid, but applied the data where it is not valid. That is, to use Mr. McPhail's first example, the candlepower at 20 feet divided by the length of the luminaire (I_a) will be greater than the candlepower per unit length (I_a) at 5 feet. Therefore this system will predict values higher than those measured.

I believe that I_a as defined, is an attempt to define the average brightness of the luminaire in terms of the candlepower. Since the candlepower varies with distance, especially in the range of distances to be encountered as room heights, and since the average brightness of the luminaire, measured *at the luminaire* does not vary, it would be more accurate to substitute this value for the I_a as defined, dividing the average brightness by π to correct the magnitude.

From Chart 1, it can be deduced that *sol* and *los* are functions of U and V as well as L/S. The data as presented can lead to significant error if one is at a point where U or V equal, 30° or 60°. *Sol* and *los* charts for other luminaires might point up larger errors. I feel that the *sol* and *los* curves should be derived from average brightness data at, for example, 10° intervals.

R. G. MCPHAIL**: Undoubtedly Mr. Losh refers to apparent candlepower in the first two paragraphs of his discussion, since true candlepower, defined as $I = dF/d\omega$,[1] does not vary with the distance. The formulae in this paper are derived on the basis of true candlepower. The substitution of apparent candlepower for true candlepower will introduce errors, as Mr. Losh states. The magnitude of such errors will depend on how closely the apparent candlepower approaches the true candlepower. Considerable thought is being given to methods of testing fluorescent units so that the apparent candlepower will more closely approximate the true candlepower, but discussion of such photometric problems is outside the scope of this paper.

Certainly there can be no objection to the substitution of the average brightness of the luminaire in the proper direction multiplied by the appropriate projected area for candlepower in the various formulae in this paper, as Mr. Losh suggests; but since average brightness is usually determined by dividing apparent candlepower by projected area no increase in accuracy would result.

As Mr. Losh points out more *los* and *sol* curves than shown on Chart 1 would be required for accurate calculation of illumination from this fixture. Actually Chart 1 is a condensation, in the interest of clarity, of nine curves of each function, taken at 10° intervals. For maximum accuracy a *los* and/or *sol* curve in the plane including the source and the point is required. For the degree of accuracy ordinarily required, however, a set of prototype curves would probably serve.

*Smitheraft Lighting Division, A. L. Smith Iron Co., Chelsea, Mass.
**Author.

1. "Illuminating Engineering Nomenclature and Photometric Standards, Z7.1-1942." Illuminating Engineering Society, New York, N. Y.

Lighting Coordinated With Structure

Produces an Excellent Office Environment

THE Swartwout Company in Cleveland needed more office space. There was some old industrial and warehouse area available but the task of transforming it into even tolerable offices seemed almost hopeless. Nevertheless, the transformation has been accomplished. It was done easily, inexpensively, and with excellent results. Electrical and most other changes were made by employees of the Swartwout Company. Mr. Roger Gilliland, Assistant Chief Engineer of Swartwout, and Mr. T. C. Sidlo, District Engineer for the General Electric Company, worked together in bringing about the modernization.

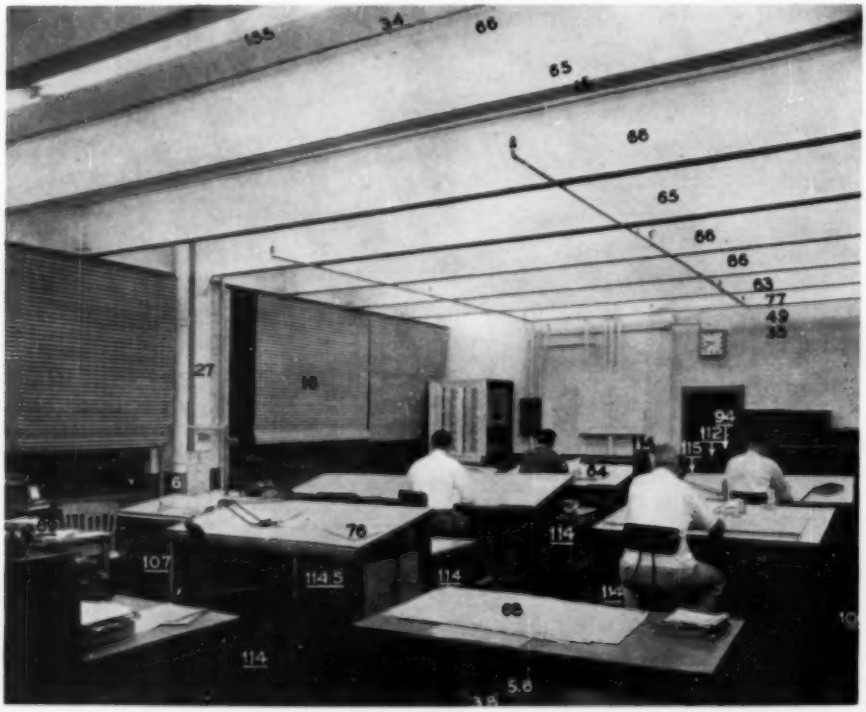
It was from space like this that the new Swartwout offices were developed.

The beams, and those portions of the ceiling not covered with acoustic tile, are painted flat white. A light, pleasant yellow is used on the walls above the blue-green dado. Two-toned green slat blinds block out daylight glare and cover the dark windows at night. Furniture and equipment have been oriented so that employees face at right angles to the beams and rows of lamps. File finishes and the asphalt tile floor are of conventionally low reflectance. The illumination in this general office area averages 63 footcandles (see luminaire detail next page). In the partitioned offices the horizontal illumination averaged 52 footcandles with a range from 45 to 58 on the desk tops. The clear glass partitions help maintain a high utilization. The balanced brightness pattern down the room permits this technique without loss of comfort.

Slimline lamps on simple channels are mounted between the 20-inch deep beams. The beams are five feet apart and provide a minimum of 27° shielding crosswise of the lamps. The 3-lamp channels are used over the drafting section while the 2-lamp units are used over the general and private office areas. All lamps are operated at 200 ma for "low brightness."

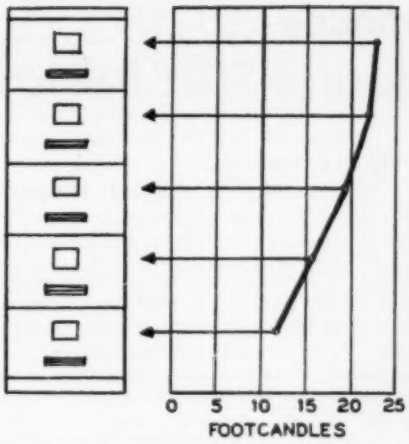
The environment in the Swartwout offices is unusually comfortable. Although lamp shielding is but 27° crosswise, lamps are scarcely noticeable and certainly not objectionable. When lamps may just be seen in one ceiling coffer, the next row nearer is at an angle of 38°-42° with the horizontal, depending upon the height of the observation point. The only other unshielded row ahead of an observer is at an angle of 58°-72°. These constitute very small areas of brightness and are considerably removed from usual sight directions. The operation of the lamps at reduced brightness and the excellence of the brightness pattern in other respects seem to compensate for what might otherwise be insufficient shielding.

Representative brightness and illumination measurements are recorded in figure below. The brightness of the beams is equal to or less than that of most tasks. This is a most favorable situation and one not often enough recognized. Large areas of

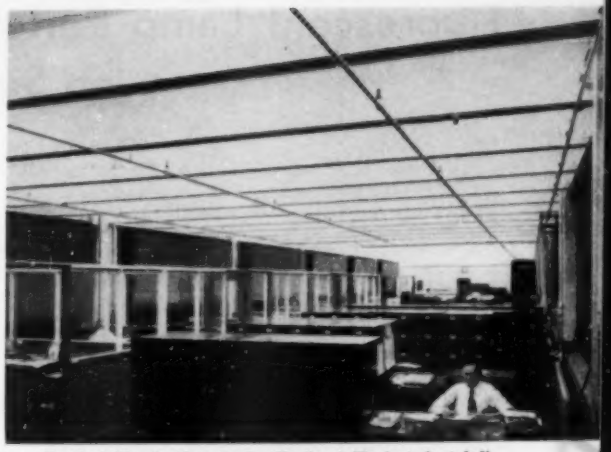


After more than six months of operation, the average horizontal illumination in the drafting section was 99.4 footcandles. The maximum was 114.5 and nearly 60% of the space received more than 100 footcandles. Measurements indicate a coefficient of utilization of close to .50.

The ratio of vertical to horizontal illumination in the center of the area varied with direction from .34 to .37 with an average of .35. Illumination values are underscored. They were obtained with a precision color-cosine corrected lightmeter.



This curve indicates the distribution of light vertically on the front of a five-drawer file.

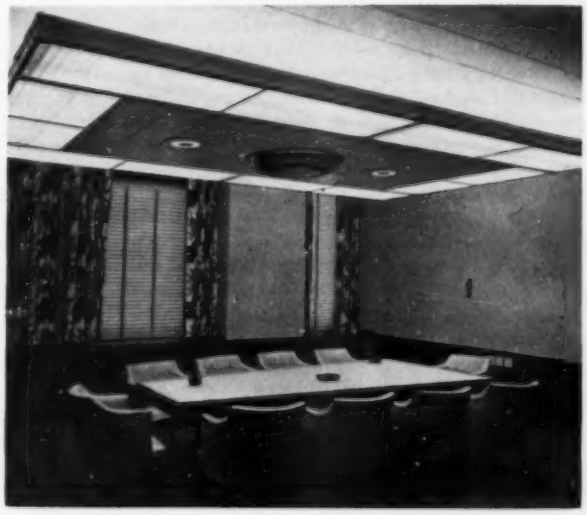


Vertical illumination on the file front illustrated at left, varied from about 20% to 35% of the general level of 63 footcandles average.

the surrounding, such as the ceiling projection, are preferable if darker rather than brighter than the task or adaptation brightness. This has been established by laboratory tests and is borne out by the results obtained in the Swartwout installation. It is comfortable in the small private offices, in the medium-sized drafting area or at the far end of the general office which exposes a vista 140 feet long. The system represents an effective coordination of lighting with structure to produce an office environment that is architecturally clean and visually comfortable. The new lighting cost the Swartwout Company just 87 cents per square foot for fixtures and lamps.

Louvers and Downlights In Conference Room

Louvered panels, 24 x 72-inch and 24 x 96-inch size, are the main source of illumination in this conference room at the Public Service Company of Northern Illinois, Chicago. Each luminaire has four Slimline T12 lamps operating at 430 ma. In addition two downlights are used over the table, each consisting of a 200-watt silver bowl lamp in Alzak reflector. Photo courtesy Lighting Products Inc., Highland Park, Ill.



Fluorescent Lamp Performance on Sequence-Start Ballasts

By D. D. HINMAN,
R. L. KEIFFER, and C. E. STRECKER

EVER since the first commercial use of fluorescent lamps there has been continuous effort directed toward a reduction in the size, cost, and power loss of ballasts which provide fast or instant lamp starting. The steady open-circuit voltage required to start a lamp is much higher than the voltage needed to regulate the lamp for normal line-voltage fluctuations after starting. Numerous circuit variations have been tried which either furnished the extra voltage needed for starting from a low-current source, or which operated two lamps in series from a ballast having only sufficient voltage to start one lamp at a time, by a sequence-starting arrangement. Our experience with both types of circuits, several years ago, indicated serious problems in lamp performance.

In recent years, new ballasts have become available which are more or less similar to the earlier circuits, but because of changes in both ballasts and lamps during the intervening years, lamp life tests have been required to determine whether these new ballasts would be satisfactory. Large numbers of these ballasts have been manufactured and put into service during the time interval required to run life tests of lamps on them, and some have given relatively short life. This paper discusses certain lamp characteristics which must be considered by the designer of a satisfactory ballast, and also the means of quickly determining whether or not a new ballast design will be satisfactory.

Lamp Starting

An instant-start ballast performs two functions; it starts the lamp and then operates it within certain limits of a specified rating. The ballast requirements essential to satisfactory operation, once the lamp is started, are rather firmly established and subject to only relatively minor variations; however, the means of starting the lamp largely determines the ballast size and cost. Since these new types of ballasts differ from previous circuits largely in the method by which the lamps are started, some knowledge of the starting process is necessary to understand their performance.

By whatever means a hot-cathode fluorescent lamp is started, two transitions must take place; first, the gas or vapor in the space between the lamp electrodes must be sufficiently ionized so as to conduct current; second, the fall in potential at the cathode, commonly called cathode drop, must be decreased from its initial high value with the cathodes cold to the low value attained during normal lamp operation. Although these two steps normally occur in such rapid succession as to be indistinguishable, they are actually separate transitions, each demanding different characteristics of the ballast. A ballast can be completely adequate to perform either one of these steps in starting and yet unsatisfactory in performing the other. The minimum open-circuit voltage requirement for instant-start ballasts is based upon the breakdown characteristics of lamps; the several factors which influence this first step of starting have been previously reported[1, 2, 3].

Many proposed ballast designs have been unsatisfactory only because they failed to perform properly the second step in starting the lamp. Energy is needed for this transition. This energy is supplied to the cathode with conventional switch start ballasts by passing current through the cathode coil, but instant-start ballasts supply energy to the lamp cathodes in a different way. At the instant of starting, the lamp has a cathode drop within the range of 100 to 200 volts which acts like a resistance load in supplying heat to increase the cathode temperature. As the cathodes warm up the cathode drop decreases to its normal value of 15 to 20 volts. Now, this arc heating of the cathodes may be accomplished either by a small lamp current for a long time, *e.g.* one second, or by a larger current for a shorter time, *e.g.* hundredths of a second. In both cases the lamp will start, but repeated slow starting will result in a much shorter lamp life than repeated fast starting.

Most fluorescent lamps, in the past, whether of

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Lamp Development Laboratory, Lamp Department, General Electric Co., Nela Park, Cleveland, Ohio, and Ballast Engineering Division, Apparatus Dept., General Electric Co., Fort Wayne, Indiana.

the switch or of the instant-start type have been operated on conventional lead-lag ballasts[4, 5, 6]. Our knowledge of lamp performance is based largely upon experience with these older types of circuits, so that any evaluation of a new ballast is by comparison with the older standards.

Sequence-Start Operation

The several variations of these circuits can be represented as in Fig. 1, and all provide essentially the same sequence of actions in starting the lamps as follows:

Step 1. Full open circuit voltage is applied to one lamp, providing initial ionization in that lamp.

Step 2. Current flow established through this lamp is limited by an impedance in parallel with the second lamp. The voltage in this paralleling impedance provides initial ionization in the second lamp.

Step 3. The two lamps run in series at successively higher currents, as the lamp impedance decreases, until stable hot-cathode operation at rated current is established.

During this starting process, each lamp goes through the basic transitions of initial ionization and of change from cold to hot cathode operation as described earlier. The sequence-start ballasts are little different from the standard lead-lag ballasts in producing the first transition, in which a minimum peak voltage is the main requirement. In lead-lag ballasts the second transition usually takes place in only a few cycles on a 60 cycle a-c supply, whereas in the sequence-start ballasts, because of lower current available to the lamps, this transition has required up to several seconds. An understanding of the interplay between lamp and ballast characteristics during this type of starting

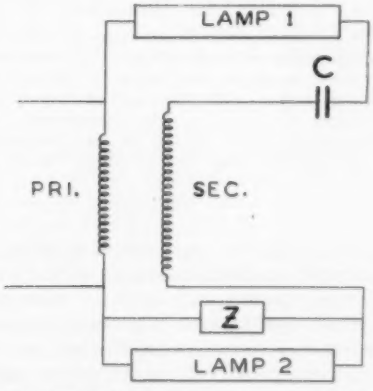


Figure 1. Simplified diagram of a sequence-start series-operate ballast.

can be gained by study of Figs. 2, 3 and 5 in which the following principles are demonstrated.

1. Two semi-stable levels of lamp voltage may occur during starting.

2. Lower currents for starting give longer starting times.

3. Ballasts having low volt-ampere characteristics may permit long continued lamp operation at one of the damaging "Cold Cathode Operation" levels of lamp voltage.

The semi-stable levels of lamp voltage may exist for minutes or hours as the current goes below 60 milliamperes, and the oscillograms of Fig. 4 demonstrate how this time increases for progressively lower currents. A lamp was considered started when its voltage reached the third or normal state of operation described in Figs. 2 and 4. Fig. 3 shows the extremely wide variation found in starting times at any given current. Part of this variation is due to lamps becoming progressively slower during life when operated with low-starting-current ballasts. Lamps which are slow for this reason can be speeded up by several days of normal three-hours-per-start operation on a standard ballast. Indications are that the slow starting causes cathode damage which affects the starting ease of the lamp even after several hours of operation at normal current.

Consideration of all these factors indicates that ballasts should be designed to provide more volts at any current during starting than is required for maximum lamp voltage. This is to insure that lamps will not "hang up" at this voltage and delay in reaching normal operating conditions. Note in Fig. 5 that the volt-ampere characteristic of a standard ballast is well above both semi-stable lamp levels; this condition gives fast lamp starting. Ballast III is considered unacceptable because it will allow long continued operation in state *A* or *B*. Ballast II is considered acceptable because it will allow little or no operation in state *A*, and only short operation in state *B*. The life tests leading to Fig. 6 bear this out.

The lamp starting ability of ballasts can be compared by measuring the current which each ballast can supply through a specified test resistor equivalent to the lamp impedance at the point of maximum current at the voltage of state A (Fig. 2). The correlation between this value of current and lamp life is shown in Fig. 6 which includes data obtained with two sizes of lamps. Even though the data are sparse, the fast drop in life below 60 milliamperes is considered real because of supporting evidence from accelerated tests not reported in this paper. At low values of starting current the duration of states *A* and *B* may vary

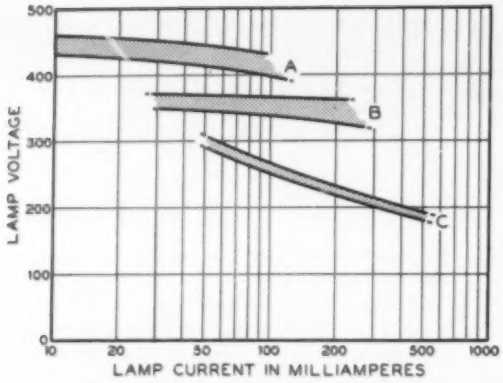


Figure 2. Volt-ampere characteristics of 96T12 lamps during the starting intervals. State A—Both cathodes cold. State B—One cathode cold—one hot. State C—Both cathodes hot—normal operation.

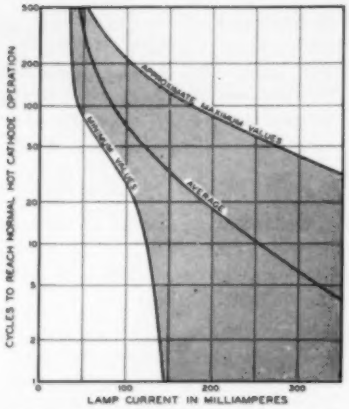


Figure 3. Cycles to reach normal hot-cathode operation for 96T12 lamps when started at various current values.

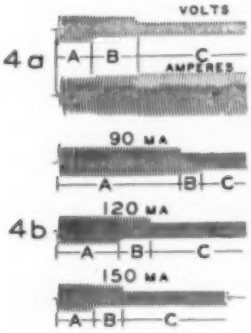


Figure 4. (Left) (a) Oscillograms of volts and amperes of 96T12 lamps during starting on a sequence-start ballast. (b) Sample oscillograms of 96T12 lamp voltage during starting at various fixed current values. The duration of states A, B, and C of Fig. 2 are shown.

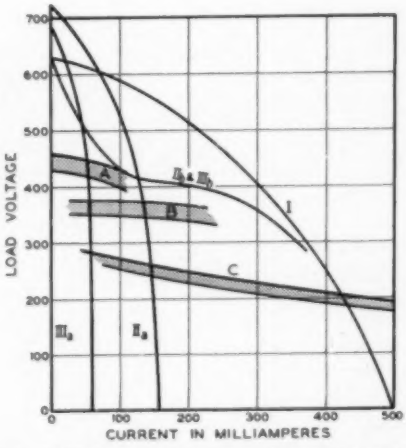


Figure 5. (Above) Volt-ampere characteristics of three ballasts using a resistor load. Lamp characteristics from Fig. 2 are shown. I—Lag ballast of standard design (lead is similar). II—Sequence-start ballast having acceptable characteristics. III—Sequence-start ballast which is unacceptable. (a) and (b) refer respectively to the 1st and 2nd lamp to start in the sequence-start ballasts.

from a few seconds to several minutes. Dr. A. W. Hull[7] has described the rapid disintegration which occurs when cathodes operate at a cathode drop greater than a certain critical value. When lamps are operated with the cathodes cold, as in states *A* and *B*, the cathode drop is greater than this critical value. Even at the normal currents available from standard instant-start ballasts, an appreciable amount of damage occurs during starting as demonstrated in the well known effect of frequent starting in reducing lamp life. The magnitude of the damage done by low starting currents is best measured by lamp life tests.

Ballast Specifications

Many cases of short lamp life found in field experience with sequence-start ballasts were a result of improper wiring. In cases where the ballast design was at fault the current available to the lamps during starting was found to be only 30 to 60 milliamperes. The fact that these ballasts complied with the existing specifications and yet gave poor lamp performance indicates the need for additional specifications. The sequence-start ballast is a step toward the worth-while goal of reduced ballast cost and losses, and its designers should be encouraged to continue its development. The following proposed specifications are an at-

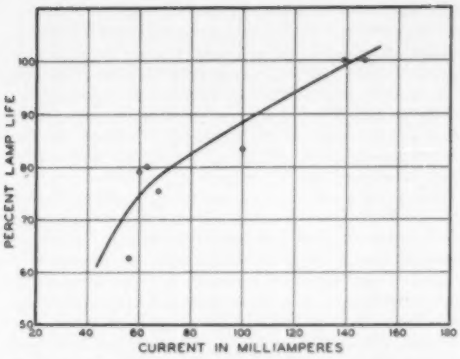


Figure 6. Life of the 48T12 and 96T12 lamps vs the current supplied by the ballast to resistors of 2750 and 4000 ohms respectively.

tempt to express the minimum ballast characteristics necessary for satisfactory lamp starting, in a simple, easily measured form.

It is difficult and somewhat impractical to specify ballast characteristics by speed of lamp starting or by watts dissipated in the cathode during starting, though these are the prime factors involved. The volt-ampere characteristic of a ballast gives a direct indication of the current which can be supplied to a lamp during its various starting stages. Present specifications determine the open circuit voltage which is one point on the ballast volt-ampere characteristic. One additional point would fairly well define it and restrict against poor ballast designs. A very practical choice of this point is the voltage and current supplied to a resistor chosen to represent the lamp impedance with cathodes operating cold.

The 4000-ohm value used for 96T12 lamp ballasts in obtaining the data for Fig. 6 can be calculated from the 100 milliampere lamp operating voltage (265V) less the normal cathode drop (15V) plus the typical cathode-drop with the cathodes cold (150V). At 100 milliamperes the voltage drop across 4000 ohms is 400 volts. Table I lists resistance values for other sizes of lamps calculated by the same method. It should be understood that these resistor and current values are merely a convenient means of fixing the volt-ampere characteristics of the ballasts, and although their approximate value can be derived from the type of data shown in Fig. 5, the final choice of acceptable values depends upon the results of lamp life tests. All of our life tests with sequence-start ballasts have been confined to 48T12 and 96T12 lamps, but a knowledge of lamp characteristics has permitted a reasonable extrapolation to include other sizes.

TABLE I.—Proposed Values of Current and Resistor to Determine Acceptable Starting Characteristics of Fluorescent-Lamp Ballasts. Ballasts must furnish the stated minimum current to the specified resistor at 90 per cent of rated supply volts.

Lamp Size	Lamp Operating Current Milliamperes	Test Resistor Ohms	Minimum Milliamperes
42"T6	120	3000	75
	200	3000	90
	300	3000	100
64"T6	120	4000	75
72"T8	200	4000	90
	300	4000	100
96"T8	120	5000	75
	200	5000	90
	300	5000	100
48"T12	425	2750	100
72"T12	425	3400	100
96"T12	425	4000	100

A difficulty arises in connection with those lamps which have multiple current ratings. Standard ballasts, designed to operate T6 and T8 lamps at currents of 120 and 200 milliamperes, furnish lower starting currents than are predicted to be necessary for good lamp starting by the methods discussed above. Operation of these lamps at both 120 and 200 milliamperes on standard lead-lag ballasts has given good lamp life. Life tests at various currents from 120 to 425 milliamperes show approximately constant life for these lamps when operated for three hours per start. It seems likely that this apparent independence of lamp life and operating current is caused by the chance equality of two opposing factors. The loss in potential lamp life, each time a lamp is started, is greater for small starting currents, whereas the loss in potential life for each hour of operation is less for smaller operating currents.

Because there is an immediate need for specifications to control the design of ballasts for all sizes of instant-start lamps, we are proposing limits for ballasts which operate lamps at either 120 or 200 milliamperes, which are based upon the volt-amperes available from standard design lead-lag ballasts which are known to give good lamp performance.

The volt-amperes available from a sequence-start ballast will change depending upon whether the other lamp position is open-circulated or loaded with a lamp. It is intended that the minimum currents listed in Table I shall be furnished both with and without a lamp in the other position. Of course, the number two lamp (Fig. 1) cannot start unless there is a lamp in the number one position, so that for this position there shall of necessity be a lamp in the number one position when making the resistor test.

Although there have not been available any sequence-start ballasts which meet the proposed specifications, lamp life tests have been made with ballasts furnishing starting currents about ten percent lower than the proposed values. These tests indicate that a ballast, meeting the proposed specifications, will give good lamp life not only when operated at rated voltage, but also at the low line voltages often encountered in service.

Summary

The failure to consider lamp starting characteristics by a ballast designer can result in poor lamp performance. The mere ability to start lamps is insufficient to avoid short lamp life.

The need for specifications to regulate the design of sequence-start ballasts is amply demonstrated by the poor lamp performance obtained with some ballasts which comply with existing specifications. Some reduction in lamp life from the standard obtained with conventional ballasts is economically justified by the lower cost and power losses which can be obtained with the sequence-start ballast. The current supplied by a ballast to a specified test resistor is at least an approximate measure of relative lamp life, and, because of its ease of measurement, a useful means of specifying ballast characteristics. The suggested values of current and resistance will result in a small reduction in lamp life, but still permit worthwhile savings in ballast size and cost.

References

1. J. A. Linder: "The Starting of Fluorescent Lamps," *Trans. Electrochemical Society*, Vol. 87, p. 379 (1945).

2. R. N. Thayer and D. D. Hinman: "Requirements for Reliable Instant-Starting Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XL, p. 640 (1945).

3. T. C. Sargent and R. H. McFarland: "Humidity Effect on Instant Starting of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLV, p. 423 (1950).

4. R. F. Hayes and D. S. Gustin: "Alternating Current Circuits for Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XXXV, p. 938 (1940).

5. C. W. Kronmiller: "Control Equipment for Discharge Type Lamps," ILLUMINATING ENGINEERING, Vol. XXXIX, p. 849 (1944).

6. R. N. Thayer: "Ballasting Requirements for Fluorescent Lamps," *Trans. Electrochemical Society*, Vol. 83, p. 113 (1943).

7. A. W. Hull: "Gas-filled Thermionic Tubes," *AIEE Transactions*, Vol. XLVII, p. 798 (1928).

DISCUSSION

EVERETT F. KELLEY and ARTHUR W. WEEKS*: The authors have presented a very interesting and constructive paper in which they have clearly analyzed the problems of sequence-start ballasts. They have also provided some basis for a common meeting ground between ballast and lamp manufacturers.

It has been a rather well-known fact that sequence-start ballasts of previous designs have usually had an adverse effect upon lamp life, often reducing the life of the lamp to 50 per cent of normal rated life. The authors explained why lamp life is adversely affected by these ballasts of unsuitable design, but do not state whether there is any visible evidence that the lamps have progressed through state A or B prior to starting, as shown in Figure 2. Inability to determine this condition visually by end or tube glow has often led to the stripping of cathode coating where lamps have been left in the socket under such conditions until they fail.

This paper shows the need for further investigation of the correlation between actual lamp life and the results of measurements on the 4,000-ohm test resistor. Although there appears to be some question that the resistors will duplicate lamp impedance conditions in a completely satisfactory manner, it does seem that the resistance testing will provide more satisfactory results than experienced in the past. Figure 6 shows that to obtain 100 per cent rated life, a 48T12 or a 96T12 lamp should receive a minimum of 140 ma to start properly. It appears that this goal has not been reached with any of the ballasts described, as Table I lists 100 ma as the minimum acceptable value, which according to Figure 6 would provide only 88 per cent lamp life. Are the values shown in Table I those on which the C.B.M. specification for sequence-start ballasts have been based, or does that specification carry a higher minimum ma value which would give 100 per cent rated life? This point is rather confused because of two statements made by the authors. One of which reads:

"Because there is an immediate need for specifications to control the design of ballasts for all sizes of instant-start lamps, we are proposing limits for ballasts which operate lamps at either 120 or 200 milliamperes, which are based upon the volt-amperes available from standard design lead-lag ballasts which are known to give good lamp performance."

The last sentence of this paper seems to contradict this theory. Clarification as to the expected life of lamps on sequence-start ballasts appears very desirable at this time. This is quite important in view of the adverse publicity earned by previous types of sequence-start ballasts.

This paper is based on the premise that reduced lamp life on sequence-start ballast operation is due to the effects of starting conditions produced by these ballasts. Although no comparison is made between the effects of burning hours on lead-lag or sequence-start ballasts, it appears that the authors are inclined to have the reader receive the impression that the effect on burning hours is no different with one type of ballast than the other. Is that really the intent of this paper, or is there a difference in the effect of burning hours as well as in starting characteristics? We have never known of trouble where the lamps on sequence-start burned continuously or near continuously. All of our tests which indicate adverse operation were made on 3-hour starts. This would be an interesting point to clarify, as there are an appreciable number of installations where the lamps burn 8 hours or more per start.

JAMES H. MCCULLOCH*: For years incandescent lamp manufacturers and users have realized that long lamp life was not an unmixed blessing. The year in year out cost of a lumen is much more interesting to this writer than plain lamp life. In fluorescent lighting, too, the actual cost of a lumen seems to have more significance than does long lamp life.

*Champion Lamp Works, Lynn, Mass.

*Design Engineer, Ballast Engineering Division, General Electric Co., Fort Wayne, Indiana.

In trying to make a sincere estimate of the costs of a proposed installation, it was found that consideration of lamp life, ballast loss, initial cost (interest and amortization), labor for replacement, air conditioning (interest, amortization and operation), freight rate (interest and amortization of increased cost) would not be out of balance if lamp life were shortened by as much as a half (caused by operation on a highly criticized ballast circuit) instead of the "conservative" estimate of "as much as one third loss of life."

Until further data are available this writer must remain of the opinion that the life of a lamp, when used as a criterion of quality, is too often an over-emphasized factor.

ABNER BYER*: The data given in the paper show that with the slimline type hot cathode lamp, lamp life is shortened with certain type of series sequence ballasts. Now, with the standard cold cathode lamp which both starts and operates with cold cathodes, and which is not affected by lamp starts, is it not possible to utilize the lower cost, lower loss, sequence-start ballast without adversely affecting lamp life?

H. U. HJERMSTAD**: I have studied and attempted to put into use the suggested methods of testing ballasts as described in this paper. I agree that starting time and energy must be considered. Apparently slow starting of the lamps will result in shorter lamp life due to the positive ion bombardment in that the cathodes of the lamp are neither hot nor cold. I do not agree that the lamp starting ability of a ballast can be correctly tested by measuring the current through a specified test resistor. This may be a convenient form of production testing of a certain type of ballast construction but it certainly should not be used as the basis of design, qualification or certification since *all lamp* and *ballast* designs are not alike.

I would like to use the resistor since it represents a stable reproducible device, but two basic fundamentals cannot be overlooked —

1. — Any gaseous discharge lamp has a very negative resistance characteristic and represents to an electrical circuit a negative resistance load. The substitution of a resistor having a fixed positive linear value will not reflect the *true* starting and operating characteristics of the lamp.

2. — A great many ballast designs are non-linear electrical net-works. To use a linear load on them will not reflect their true operating values when a dummy resistor load is used. For example, it is impossible to determine the watts output of a ballast on a resistor load, lamps must be used. I have a number of oscillographs of ballasts which do not meet the resistor load specification but they will start lamps, and bring them to their operating currently quickly. I also have oscillographs of a ballast which meets the resistor requirement but in turn has a long starting time when lamps are in the circuit.

There are several models of direct recording oscillographs on the market that will give excellent recordings of the energy and starting time of lamps. Since there are methods of instrumentation which enable lamps to be used as the basis of determining the starting characteristics of ballasts, they should be tested with their true or actual load.

I would suggest that we use as a basis of determining the starting characteristics of lamps and ballasts, the proposed American Standard lamp ballast (the same as now used to determine lamp wattage), for the type of lamps in question and a direct recording oscillograph such as the Brush Model 932 d-c amplifier and the BL-202 two-channel recorder.

The basic requirement simply can be that — The starting time of any lamp of any make on any ballast be no greater than 130 per cent of the time and not less than 40 per cent of the energy as shown by oscillograph curves taken on a standard ballast.

GEORGE E. EVANS*: Although the development of sequence-start ballast circuits, application troubles experienced with them, and action necessary to correct these troubles—all are of strict technical nature, the discussion I wish to offer is primarily concerned with non-technical aspects of this problem. This is so not only because there will be considerable technical discussion, but also because I believe the time has come to give certain assurances to the many users of series-sequence ballasts who have had undeniable operational difficulties with them.

No better place and time could be found to do this than here and now. In so speaking, I am not presuming to be industry spokesman. I am offering these assurances merely as one who has been close enough to the problem to believe that they can, and should, be given.

In common with most of you, I have been very proud of the honest and progressive spirit that characterizes the lighting industry and results in utmost regard for the consumer and his problems.

Therefore, the first assurance to be offered is that the situation surrounding the series-sequence ballast does not represent a departure from this concept of responsibility. These ballasts were honestly introduced with the belief that the user would benefit and that service with them would be satisfactory. Everyone regrets that the status of technical know-how was inadequate to predict the troubles that resulted.

Secondly, I want to offer assurance by pointing out that safeguards are being erected to prevent—as far as is possible—a similar occurrence of such wide effect. These safeguards are being created by industry-wide committee action.

Third, every possible study is being made to correct the design faults of series-sequence circuits. This paper is an excellent example of these studies. Because of the magnitude of the problem, including the extended time necessary to get life test data, it is too early to say that all the answers are known. You may be confident that the ingenuity of ballast and lamp engineers will provide the necessary solution.

Fourth, some assurance must be given to those of you who now have installations of series sequence ballasts with which trouble has been experienced. You will not be neglected. Every effort will be made to provide lamp designs which will give satisfactory service. The goal may not be reached overnight, but its accomplishment is believed possible. In fact, industry studies now being conducted will not only solve the present difficulties, but probably will result in giant strides of benefit to the lighting industry.

All in all, when we engineers fail to do a complete job, our customers are forced to complete the job for us. We don't intend to create such competition in the engineering field.

In closing, I would like to ask Mr. Keiffer a technical question. Series-sequence ballasts have given field trouble because the energy delivered to the lamp at starting is too low, being much lower than that delivered by lead-lag

*Cold Cathode Lighting Corp., New York, N. Y.
**Sola Electric Co., Chicago, Ill.

*Westinghouse Electric Corp., Bloomfield, N. J.

ballasts. If an instant-start ballast circuit were available which delivered considerably more starting energy than does the conventional lead-lag type what would be the effect on lamp life?

R. L. KEIFFER*: As Messrs. Kelley and Weeks suggest, there is a need for additional investigation of this subject, not only to determine the correlation between lamp life and the values of resistor current, but also to find other and better ways of quickly determining whether a ballast will give good lamp performance.

The C.B.M. specifications are based upon the values given in Table I for T12 lamps, which apply at 90 per cent of rated voltage. The current value used in Figure 6 was the one measured at the supply voltage of the life test, thus, at rated line voltage, a ballast which just meets the specification will furnish approximately 110 milliamperes to the resistor. For this current Figure 6 predicts 92 per cent of the lead-lag ballast lamp life. Duplicate tests to determine the life ratio on two types of ballasts have had a spread of ±10 per cent from the average value. A similar tolerance probably should be applied to any life ratios obtained either from Figure 6 or from an actual life test.

On continuous operation, the same factors influence lamp life with sequence-start ballasts as with any other ballast. The decrease in lamp life which we have discussed in this paper is the result of starting. The tests upon which Figure 6 is based were all made at three hours operation per start. Less frequent starting would give a smaller difference in life, and more frequent starting a greater difference.

Mr. McCulloch questions the importance of long lamp life, and the authors acknowledge that the lower cost and other advantages of sequence-start ballasts economically justify some reduction in lamp life. Although cost of light calculations are a useful guide, they are not suitable to determine a point on the curve of Figure 6 toward which the specifications should be aimed, since a ballast which gives some minimum level of lamp performance is not necessarily accompanied by a low price tag.

Mr. Byer asks about the use of sequence-start ballasts with cold-cathode lamps. Our paper applies only to the hot-cathode type of fluorescent lamp, and we have had no experience with the use of sequence-start ballasts with cold-cathode lamps. However, we would expect low-current starting not to have much influence upon cold-cathode lamp life.

We agree with Mr. Hjermstad's contention that a resistor is not the equivalent of a lamp in a ballast circuit. The proposed resistor is an approximate substitute for a lamp, which results in a relatively simple means of testing ballasts. The justification for its use is based upon the reasonably good correlation between resistor current and lamp life, and the lack of *any* alternative method.

The suggestion that relative lamp starting time be used as a ballast specification is untenable in the proposed form. A particular ballast, which has given short lamp life, starts new lamps faster than an A.S.A. reference ballast. This may seem to be a complete contradiction of our argument that fast starting is necessary for long lamp life, but actually it is not. This same ballast, after operating a lamp for a thousand hours with several hundred starts, is no longer able to start the lamp quickly. The ballast has changed the lamp's characteristics! A ballast which gives good lamp life continues to start the lamp fast throughout its life, and a lamp operated on such a ballast is less altered in starting characteristics than a lamp operated on a poor ballast.

It is possible that a method can be developed to use lamp starting time as a criteria for judging ballast quality, but such a method will require some means of rapidly aging lamps to reproduce the starting characteristics which result from long operation, and some means of reducing the random variations in starting time, so that a few starts on a few lamps will yield dependable results.

*Author.

Office from Former Storeroom

Conversion of this former storeroom to a small office at the Democrat and Chronicle, Rochester, N. Y., was accomplished by installing a louvered ceiling, which covered old pipes; and the use of light green drapes and carpeting, and plywood walls with a striate design. Maintained level of illumination after nine months is 75 footcandles, using 48-inch and 96-inch single lamp strip with 40-watt T-12 3500K lamps. Installation was made by the newspaper maintenance crew, assisted by Fred Elley, Rowe Electric Corp., and Floyd Owen, Rochester Gas & Electric Corp.

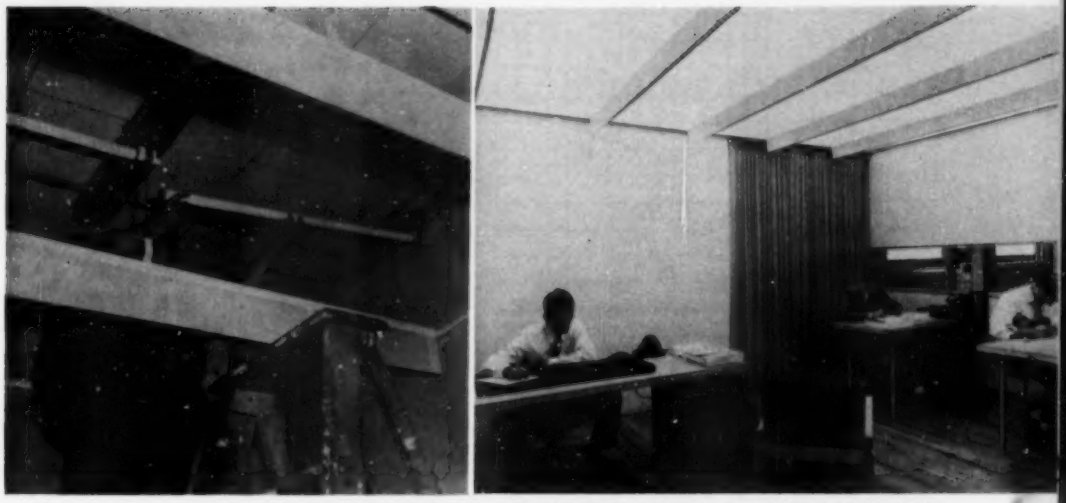


Figure 1. The integration of sound control and lighting is shown in the photo (left); acoustical baffles are suspended directly from the socket support. Ceiling and baffles, as installed in the Job Engineering Dept. of the F. W. Wakefield Brass Co., are shown above

Light and Sound Absorption

By T. D. WAKEFIELD

EVERY illuminating engineer doing layout work has at one time or another collided with some phase of acoustics since lighting and sound conditioning are often closely associated in an office interior. Troffers with suspended acoustical ceilings have been in use for many years. Luminous acoustical ceilings bring acoustics even more directly into the ken of the illuminating engineers, because the newest luminous acoustical ceilings are suspended from the electrical system (see Fig. 1).

Some of them combining luminous sources and acoustical absorbers make use of suspended acoustical material. Such baffles serve not only as acoustical baffles but also as lighting baffles.

Owing to diffraction, the effective absorption per unit area or per unit weight of small suspended absorbers can be very high. Sound waves impinge on both sides of the absorbers thus enhancing their absorption over a single surface. Such devices can very well have effective absorption co-efficients greater than unity, which to the illuminating engineer is like having a reflection factor greater than 1.00.

One acoustical baffle now available measuring only six inches deep, has the following absorption rates; at 128 cps. the absorption co-efficient is .33; at 256 cps., .42; 512 cps., .93; 1024 cps., 1.11; 2048 cps., .87; and at 4096 cps., the co-efficient is 1.38. The noise reduction co-efficient is .90. The noise reduction co-efficient is the average of the co-efficients of frequencies from 256 to 2,048 cycles inclusive given to the nearest five per cent.

Absorption Rather Than Reflection

Like lighting layouts, sound control layouts are in practice not quite as complicated as text books would indicate. In fact, practical applications of acoustics are simpler than lighting layouts.

Unlike lighting, the acoustical engineers are in-

Author: Vice-President, The F. W. Wakefield Brass Company, Vermilion, Ohio. Member, The Acoustical Materials Association.

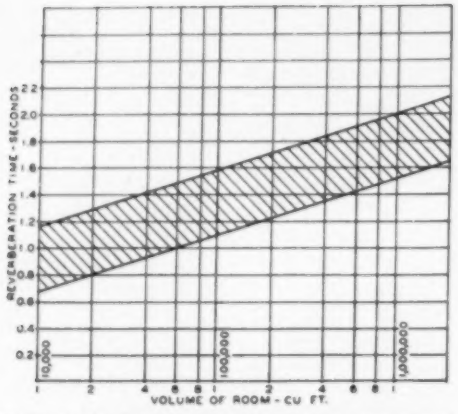


Figure 2. Acceptable reverberation times for rooms of various sizes for the frequency of 512 cycles per second are shown by the shaded area.

terested in what is absorbed rather than in what is reflected. Rather than the reflection co-efficient, sound people are interested primarily in absorption co-efficients.

From there on, the matter of reverberation reminds the illuminating engineer of interflection. There is little which can be done to control noise direct from the source to the ear but the supplier of acoustical material has a wide choice of materials and methods of application to absorb the sound which bounces in intricate patterns, just as with light.

The primary objective is to control the reverberation. Reverberation is a function of the volume of the room. W. C. Sabine worked out the simple formula $T = \frac{.05\,V}{a}$ to calculate reverberation time. V is the total volume of the room in cubic feet and a is the total equivalent absorption of the boundaries and contents of the room; a is expressed in units of absorption technically known as sabins, but generally called "units." The absorption of the surface is the product of the area of the surface multiplied by its known sound absorption co-efficient.

Acceptable reverberation times are found in the shaded area in Fig. 2 which plots reverberation time in seconds against volume of the room in cubic feet.

To compute a for any room, the area of each surface is multiplied by its absorption co-efficient, and the sum plus the absorption due to objects within the room makes the total absorption, the a of the formula. A numerical example shows how simple it is to calculate the reverberation in a simple rectangular shape.

For a business space 40 ft x 65 ft x 14 ft, the total volume would be 36,400 cubic feet; and sound absorption of the room surfaces would be:

	Dimension	Area	Co-ef.	Absorption
Floor, rubber tile	40′ x 65′	2600	.05	130
Walls, wood panelling	14′ x 210′	2940	.06	176
Ceiling, plaster	40′ x 65′	2600	.03	78
Draperies	12′ x 20′	240	.50	120
Luminous acoustical ceiling	40′ x 65′	2600	.40	1040
Total absorbing power				1544

Applying the Sabine formula,

$$T = \frac{.05\,V}{a} = \frac{.05 \times 36{,}400}{1{,}544}$$

the reverberation time for the room would be 1.2 seconds. Plotted on the chart, Fig. 2, we find that this reverberation time is highly satisfactory for a room of this size, and that no additional acoustical treatment would be desirable. Sound absorption co-efficients are readily available in Bulletin XIII of the Acoustical Materials Association.

The Riverbank Laboratory of the Armour Research Foundation is the recognized source of data in the acoustical world. All important acoustical materials are tested there under identical conditions and the co-efficients of absorption for various cycles per second are given in Bulletin XIII along with the noise reduction co-efficient, which is the figure used in calculating absorption of material.

The noise reduction co-efficient is recommended for use in comparing materials to be applied in offices, hospitals, banks, corridors, etc. Auditorium treatment gets into complicated sound analysis and should not be experimented with by the illuminating engineer.

Illuminating engineers interested in further information on the use of acoustical materials should have not only Bulletin XIII but also "Theory and Use of Architectural and Acoustical Materials."

Bibliography

1. Sound Absorption Co-efficients of Architectural and Acoustical Materials, "Bulletin XIII, 1951." Acoustical Materials Association, 59 East 55th Street, New York 22, N. Y.

2. "Theory and Use of Architectural and Acoustical Materials." Acoustical Materials Association, 59 East 55th Street, New York 22, New York.

3. "Acoustical Designing in Architecture." Vern O. Knudsen and Cyril M. Harris, John Wiley and Sons, Inc., New York, New York, 1950.

An Analysis of Fluorescent Luminaire Brightness

By JOHN J. NEIDHART

DURING the past decade there has been an increasing awareness of the need for brightness control if a comfortable visual environment is to be attained. Obviously, the control of brightness must begin at the luminaire, and some of our national committees have attempted to guide the luminaire designer, application engineer, and user by recommending maximum brightnesses and/or shielding angles. One committee is charged with the responsibility of preparing illumination performance recommendations for luminaires. All of these groups have been forced to use *maximum* brightness at specified angles or in specified zones as their criterion, because it is the only currently accepted method of measuring and reporting brightness.

Concurrent with the efforts of these committees, other groups and individuals have approached the problem from the standpoint of mathematically predetermining whether a given installation of luminaires would be comfortable or uncomfortable. Although differing in many respects, the methods derived by those using this approach have one thing in common — they are, for practical reasons, based upon *average* brightness.

Thus we find an anomaly. The first group is hampered by lack of sufficient data to verify any limits they may establish, and they cannot resort to the work of the second group because there has been no correlation between *maximum* and *average* luminaire brightness.

Maximum Brightness

Maximum brightness data from the various laboratories are currently being accepted as a reliable indication of luminaire performance. Few people realize that these data may be of questionable accuracy and may not be a true maximum found by thorough and conscientious exploration. Several photometric curves of different manufacturers' equipment have come to the author's attention in which the "maximum" value reported at 0° for an open, louvered bottom luminaire was well below the rated brightness of the lamp which would be fully exposed at that angle. Our laboratory has found that the value at 0° consistently *exceeds* the rated lamp brightness because of buildup from adjacent lamps and reflecting surfaces. Even when the measurements are made conscientiously by skilled technicians, however, maximum brightness measurements are very tricky and may be altered to a considerable degree by small mechanical variations in the equipment and its shielding media.

To add to the confusion, the various photometric laboratories are using different methods of measuring maximum brightness which yield results that are not comparable. The "I.E.S. Guide for Photometric Testing of Fluorescent Luminaires — 1948" requires only that the maximum brightness at each test angle be a "measurement of the average brightness of a one-inch square or of one square inch rectangular area with the major dimension selected to suit the particular area being measured but not exceeding four inches. The method and area measured should be stated." To show the extreme differences in the results that may be obtained from the various test methods in current use, four different sets of brightness measurements were made for a direct-indirect luminaire with a 30° x 30° louver bottom. Readings were taken with a photo-electric type meter having apertures of 1" x 1", ½" x 2", and ¼" x 4" and the cells located two feet from the aperture. A set of readings was also obtained with a visual type meter (Luckiesh-Taylor) since this is being used by at least one laboratory for all of its brightness measurements. The data obtained from these tests are shown in Table I. To facilitate comparison, relative brightnesses have also been tabulated taking as unity the brightness obtained with the 1" x 1" aperture at each angle. It is apparent that, in general, as the shielding angle is approached, the narrower the aperture, the higher the reading. This would be expected because the narrower apertures *when properly oriented to obtain a maximum reading* "see" mostly lamp brightness without averaging in the lower brightness of the shielding media. The visual type meter is comparable to an extremely small, narrower aperture, but the readings are less reliable than those ob-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Author: Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio.

TABLE I.—Comparison of Maximum Brightnesses for a Direct-Indirect Luminaire with 30° x 30° Louver Bottom Using the Different Techniques Approved in the I.E.S. Test Procedure or in Common Laboratory Use.

Angle	Viewing Direction	Photo-Electric Type Meter						Visual Type Meter (Luckiesh-Taylor)	
		1" x 1" Aperture		½" x 2" Aperture		¼" x 4" Aperture			
		Footlamberts Brightness	Relative Brightness	Footlamberts Brightness	Relative Brightness	Footlamberts Brightness	Relative Brightness	Footlamberts Brightness	Relative Brightness
0°	——	2033	101	2064	102	1940	95	2141	105
30°	Crosswise	2168	100	2262	104	2207	102	2223	103
	Endwise	1986	100	1986	100	1627	82	1923	97
45°	Crosswise	1579	100	2074	131	2010	127	2178	138
	Endwise	1752	100	1335	76	1302	74	1918	109
60°	Crosswise	656	100	885	135	1038	158	1217	186
	Endwise	775	100	723	93	651	84	1436	185
75°	Crosswise	211	100	257	122	281	133	289	137
	Endwise	268	100	268	100	234	87	303	113
90°	Crosswise	710	100	360	51	1126	158	1056	149
	Endwise	—	—	—	—	—	—	—	—

tained with a photo-electric meter and it is very difficult to explore and be certain that the true maximum has been found. Even so, the brightness of such a small area can hardly be considered representative and there is a tendency for the laboratories using this device as their test instrument to select by visual observation an area that might be considered as representative. Such a procedure can hardly be regarded as very scientific or as a satisfactory means of determining whether a given luminaire satisfies a set of limiting brightnesses that may be established.

Another false appraisal of luminaire brightnesses that is frequently introduced is the use of readings taken in the field with a visual type meter. Such data are not only subject to the disadvantages described in the preceding paragraph, but are completely unreliable as an absolute measure of luminaire performance because they are based upon lamps operating under unknown conditions. If the data are to be used to determine compliance with recommended luminaire brightness limitations, they must be taken in the laboratory with carefully calibrated lamps operating on a non-fluctuating power supply.

Average Brightness

The average brightness of a luminaire is merely the candlepower at a given angle and viewing direction divided by the projected area (in square inches) of the *luminous portions* of the luminaire at that angle and direction. The brightness thus obtained will be in candles per square inch and may be converted to footlamberts by multiplying by 452. The accuracy of average brightness data is obviously dependent upon the accuracy of the projected area calculations and the candlepower measurements. The projected area at any angle for crosswise or endwise viewing may be obtained graphically and/or mathematically with reasonable ease and accuracy. Candlepower measurements are inherently more reliable than direct brightness readings for several reasons. (1) The relative positions of the photo-cell and the luminaire are positively fixed for each angle and plane of a candlepower distribution curve. To obtain a maximum brightness reading at a given angle in a specified plane, the proper position of the cell for a *maximum reading* must be found by exploration. A thorough exploration both lengthwise and laterally is not considered practical, so it is generally assumed that the maximum will occur at the longitudinal center of the luminaire. This assumption has not been proven valid. (2) The greater distance between the cell and luminaire used in making candlepower measurements and the fact that the entire luminaire is contributing to the reading will average out the effect of small physical variations and mechanical adjustments in the luminaire. Such variations may have a considerable effect upon brightness readings taken over a very limited area and from a close distance. (3) The distance between the brightness instrument cells and the luminaire is variable, particularly at the high angles, because of physical clearance requirements. As the distance between them increases, the cells are likely to "see" an area larger than the square inch aperture on the instrument. This error may be minimized by using an instrument with a long tube so that the cells will be two feet in back of the aperture, but much of the current published data were obtained using a one-foot tube. It follows, therefore, that average brightness data can be regarded with greater faith than can maximum brightness data.

Comparison of Average and Maximum Brightness

In Figs. 1-10, average and maximum brightnesses of several representative fluorescent luminaires

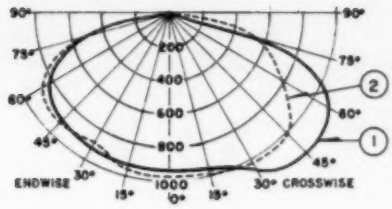


Figure 1.

Angle	Viewing Direction	Luminaire #1 Maximum Brightness	Luminaire #1 Max. to Avg Brightness Ratio	Luminaire #2 Maximum Brightness	Luminaire #2 Max. to Avg. Brightness Ratio
0°	——	2385	2.5	2245	2.3
45°	Crosswise	2530	2.3	2195	2.2
	Endwise	1950	2.2	2195	2.3
60°	Crosswise	2485	2.2	1660	2.2
	Endwise	1655	2.0	1660	1.9
70°	Crosswise	1950	2.2	875	1.5
	Endwise	1460	2.3	1410	1.8

No. 1. 2-lamp 40-watt industrial luminaires
No. 2. Same as No. 1 except with longitudinal shield

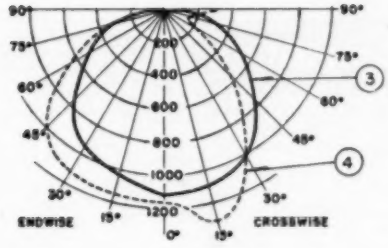


Figure 2.

Angle	Viewing Direction	Luminaire #3 Maximum Brightness	Luminaire #3 Max. to Avg. Brightness Ratio	Luminaire #4 Maximum Brightness	Luminaire #4 Max. to Avg. Brightness Ratio
0°	——	2379	2.1	1470	1.3
45°	Crosswise	1903	2.5	1045	1.9
	Endwise	1784	2.3	1405	1.4
60°	Crosswise	1189	2.4	457	3.3
	Endwise	773	1.5	1340	2.0
75°	Crosswise	595	1.8	490	3.1
	Endwise	595	1.8	751	2.2
90°	Crosswise	0	—	464	1.5
	Endwise	0	—	209	0.56

No. 3. 2-lamp 40-watt Troffer with 30° x 25° louver
No. 4. 2-lamp 40-watt Troffer with prismatic glass

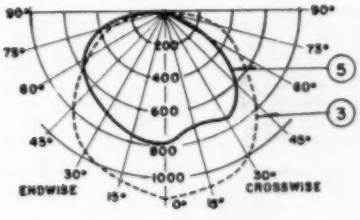


Figure 3.

Angle	Viewing Direction	Luminaire #3 Maximum Brightness	Luminaire #3 Max. to Avg. Brightness Ratio	Luminaire #5 Maximum Brightness	Luminaire #5 Max. to Avg. Brightness Ratio
0°	——	2379	2.1	2300	2.9
45°	Crosswise	1903	2.5	1630	2.9
	Endwise	1784	2.3	—	—
60°	Crosswise	1189	2.4	904	4.9
	Endwise	773	1.5	1670	3.0
75°	Crosswise	595	1.8	360 (80°)	12.0
	Endwise	595	1.8	586	1.4
90°	Crosswise	0	—	135	4.5
	Endwise	0	—	0	—

No. 3. 2-lamp 40-watt Troffer with 30° x 25° louver
No. 5. 2-lamp 40-watt surface unit with 30° x 20° louver

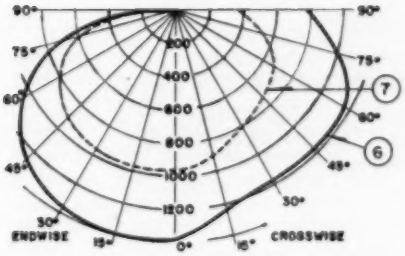


Figure 4.

Angle	Viewing Direction	Luminaire #6 Maximum Brightness	Luminaire #6 Max. to Avg. Brightness Ratio	Luminaire #7 Maximum Brightness	Luminaire #7 Max. to Avg. Brightness Ratio
0°	——	2154	1.5	1173	1.2
30°	Crosswise	2356	2.0	1238	1.6
	Endwise	2020	1.5	1113	1.2
45°	Crosswise	2390	2.0	1330	1.8
	Endwise	1818	1.5	1035	1.2
60°	Crosswise	2491	2.1	1359	2.0
	Endwise	1599	1.5	914	1.2
75°	Crosswise	2020	2.0	1040	1.9
	Endwise	1151	1.6	682	1.1
90°	Crosswise	2020	2.6	1088	2.9
	Endwise	0	—	0	—

No. 6. 2-lamp 40-watt unshielded luminaire
No. 7. 2-lamp 40-watt unshielded (low brightness lamps)

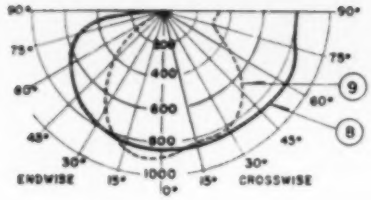


Figure 5.

Angle	Viewing Direction	Luminaire #8 Maximum Brightness	Luminaire #8 Max. to Avg. Brightness Ratio	Luminaire #9 Maximum Brightness	Luminaire #9 Max. to Avg. Brightness Ratio
0°	——	1060	1.3	2113	2.4
30°	Crosswise	—	—	2189	2.7
	Endwise	—	—	2004	2.9
45°	Crosswise	1210	1.4	2010	3.0
	Endwise	—	—	1847	3.6
60°	Crosswise	1160	1.3	822	1.9
	Endwise	675	1.1	592	1.7
75°	Crosswise	1160	1.4	371	1.2
	Endwise	530	1.2	266	2.3
90°	Crosswise	1160	1.4	742	2.3
	Endwise	0	—	0	—

No. 8. 2-lamp 40-watt surface unit with diffusing cylinder
No. 9. 2-lamp 40-watt ceiling unit with 30° x 30° louver

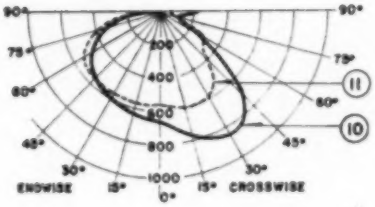


Figure 6.

Angle	Viewing Direction	Luminaire #10 Maximum Brightness	Luminaire #10 Max. to Avg. Brightness Ratio	Luminaire #11 Maximum Brightness	Luminaire #11 Max. to Avg. Brightness Ratio
0°	——	1800	2.7	1085	1.9
45°	Crosswise	1560	2.3	875	2.4
	Endwise	—	—	930	1.7
60°	Crosswise	438	1.9	330	1.1
	Endwise	825	1.7	930	1.7
75°	Crosswise	97	1.0	290	2.9
	Endwise	480	1.6	800	2.2
90°	Crosswise	97	.43	67	1.1
	Endwise	0	—	0	—

No. 10. 2-lamp 40-watt semi-direct unit with aluminum sides and 40° x 25° louver
No. 11. 2-lamp 40-watt similar to No. 10 except with low brightness lamps and 40° x 5° shielding

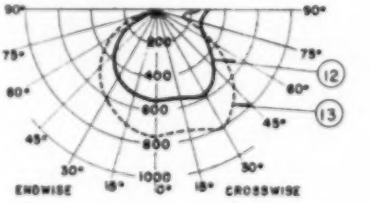


Figure 7.

Angle	Viewing Direction	Luminaire #12 Maximum Brightness	Luminaire #12 Max. to Avg. Brightness Ratio	Luminaire #13 Maximum Brightness	Luminaire #13 Max. to Avg. Brightness Ratio
0°	——	1747	3.1	2033	2.7
30°	Crosswise	1936	3.3	2168	2.7
	Endwise	—	—	1986	3.3
45°	Crosswise	1076	2.3	1579	2.4
	Endwise	1537	4.1	1752	3.7
60°	Crosswise	272	.87	656	1.8
	Endwise	838	5.1	775	2.7
75°	Crosswise	187	.73	211	1.4
	Endwise	217	4.6	268	2.4
90°	Crosswise	136	.47	710	2.6
		0	—	0	—

No. 12. 2-lamp 40-watt direct-indirect unit with 30° x 25° louver
No. 13. 2-lamp 40-watt similar to No. 12 except with 30° x 30° louver, narrower width and higher central channel

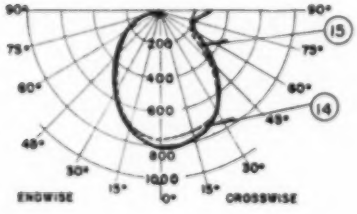
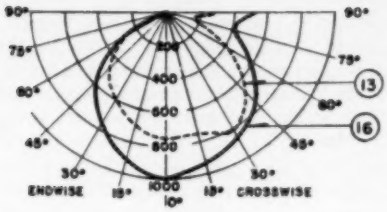


Figure 8.

Angle	Viewing Direction	Luminaire #14 Maximum Brightness	Luminaire #14 Max. to Avg. Brightness Ratio	Luminaire #15 Maximum Brightness	Luminaire #15 Max. to Avg. Brightness Ratio
0°	——	2157	2.6	2106	2.7
30°	Crosswise	2196	3.0	1924	3.8
	Endwise	1808	3.2	1820	3.4
45°	Crosswise	775	1.7	624	1.5
	Endwise	790	2.1	832	2.6
60°	Crosswise	342	1.4	251	1.1
	Endwise	333	1.4	348	1.5
75°	Crosswise	234	1.1	203	1.0
	Endwise	234	1.6	237	2.2
90°	Crosswise	683	2.2	325	1.4
	Endwise	0	—	0	—

No. 14. 2-lamp 40-watt similar to No. 13 except with X° louver
No. 15. 2-lamp 40-watt identical to No. 14 except with channel sides painted deep ivory instead of white.

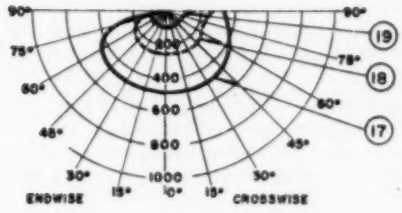
Figure 9.



Angle	Viewing Direction	Luminaire #13 Maximum Brightness	Luminaire #13 Max. to Avg. Brightness Ratio	Luminaire #16 Maximum Brightness	Luminaire #16 Max. to Avg. Brightness Ratio
0°	——	2033	2.7	2357	2.4
30°	Crosswise	2168	2.7	1996	2.3
	Endwise	1986	3.3	2150	2.8
45°	Crosswise	1579	2.4	1190	1.6
	Endwise	1752	3.7	1739	2.9
60°	Crosswise	656	1.8	326	.58
	Endwise	775	2.7	729	2.7
75°	Crosswise	211	1.4	664	1.6
	Endwise	268	2.4	338	6.8
90°	Crosswise	710	2.6	1382	2.6
		0	—	0	—

No. 13. 2-lamp 40-watt direct-indirect with 30° x 30° louver
No. 16. 4-lamp 40-watt similar to No. 13

Figure 10.



Angle	Viewing Direction	Luminaire #17 Maximum Brightness	Luminaire #17 Max. to Avg. Brightness Ratio	Luminaire #18 Maximum Brightness	Luminaire #18 Max. to Avg. Brightness Ratio
0°	——	435	.87	338	1.3
45°	Crosswise	435	.91	338	1.3
	Endwise	435	.94	—	—
60°	Crosswise	386	.88	300	1.3
	Endwise	386	.83	290	1.4
75°	Crosswise	386	1.0	290	1.3
	Endwise	290	1.0	195	1.1
90°	Crosswise	531	1.5	531	2.0
	Endwise	0	—	0	—

No. 17. 4-lamp 40-watt semi-indirect
No. 18. 2-lamp 40-watt semi-indirect

Angle	Viewing Direction	Luminaire #19 Maximum Brightness	Luminaire #19 Max. to Avg. Brightness Ratio
0°	——	107	1.3
45°	Crosswise	107	1.2
	Endwise	100	1.2
60°	Crosswise	107	1.2
	Endwise	53	.68
75°	Crosswise	107	1.2
	Endwise	53	.66
90°	Crosswise	—	—
	Endwise	0	—

No. 19. 2-lamp 40-watt luminous indirect

are compared. Several types of direct, semi-direct, direct-indirect, semi-indirect, and indirect luminaires are included to show the effects of both distribution and method or degree of shielding. The average brightness is presented in the form of smooth curves from 0°-90° using polar coordinates. The curves were drawn by plotting the brightnesses calculated for every 15° interval. Maximum brightnesses at specified angles are tabulated beside each set of average brightness curves. The maximum brightnesses were measured in the laboratory with an instrument having 1" x 1" aperture. All brightness data are shown for both crosswise and endwise viewing.

To facilitate comparison of maximum and average brightnesses, the ratio of maximum to average brightness is tabulated for all angles for which maximum brightness data were available. It may be noted that the ratio varies from 0.43 to 12.0 for the various luminaires studied. With only a few exceptions, however, the maximum brightness is from 1.5 to 5 times as much as the average brightness. The exceptions are in some cases difficult to explain, but the most outstanding ones are probably due to inaccuracies in measuring the maximum brightness. Some of the data were obtained several years ago when the brightness measuring instrument was hand-held and it was difficult to maintain the proper angle and be sure that the true maximum for that angle was being obtained. Furthermore, the data were taken by different laboratories using somewhat different techniques, and it is quite probable that complete explorations were not made at each angle to find the true maximum—particularly in those instances where the "maximum" is less than the average brightness.

Analyzing Average Brightness Data

A study of the data shown in Figs. 1-10 seems to indicate that average brightness is a satisfactory means of indicating fluorescent luminaire performance as it may affect comfort. In Fig. 1, for example, the improvement resulting from the addi-

tion of a longitudinal shield to a two-lamp 40-watt industrial luminaire is clearly shown. Fig. 2 shows that the use of prismatic glass in a troffer can result in materially lower brightnesses at normal viewing angles than would be obtained with louver bottoms but the improvement is offset somewhat by higher brightnesses in the reflected glare zone. Since the same scale has been maintained for all of the figures, the curve for luminaire No. 3 may be compared with the curve for luminaire No. 1 to study the effect of a deeper reflector and a louver bottom. This type of comparative analysis can be made for all of the curves shown. To facilitate direct comparison of two or more curves shown in different figures, it is suggested that one of the curves be roughly traced on a small piece of tracing paper so that the tracing can be laid over any of the curves with which it is to be compared. Space limitations will not permit a detailed discussion of the possible comparisons and conclusions that may be drawn. The difference between the curves in Fig 3, however, requires explanation since the reason for this difference is not apparent from the descriptive information provided. The difference is attributable to both of the factors that enter into the calculation of average brightness—candlepower and projected area. Luminaire No. 5 has somewhat lower candlepower values (particularly near vertical) than does luminaire No. 3, and the area of No. 3 is greater because it is wider and is luminous over its entire depth.

Average, Maximum, or Both?

Whether or not average brightness alone is a sufficient means of reporting or specifying luminaire brightness is subject to conjecture. It does appear to be more useful and indicative of luminaire performance than the maximum brightnesses that are now used exclusively. Average brightness is more representative of what the eye sees and is affected by. Smooth curves covering the entire viewing zone are easier to compare than isolated maximum values which are often not even at the same angles. Furthermore, the average brightness can be readily computed for any luminaire for which candlepower distribution curves and complete dimensional data are shown; no additional photometric test data are necessary.

It is hoped that the data and discussion presented in this paper will lead to the adoption of a more satisfactory method of appraising and specifying luminaire performance from the standpoint of brightness. The many shortcomings of the currently used maximum brightness data do not seem to justify the importance that has become attached to such data. The possible use of average brightness as a criterion certainly merits study by the previously mentioned committees. The low ratios of maximum to average brightness shown in this paper indicate that for the wide range of luminaires studied, there are no excessively bright "hot spots" that would cause glare but would not significantly affect the average brightness because of their small area. This would be expected from fluorescent luminaires, but it is possible that the ratio of maximum to average brightness would be more significant for some types of incandescent luminaires. Additional studies should, therefore, be made to determine whether average brightness alone would be satisfactory for incandescent luminaires. It is believed that there is sufficient information reported herein to justify switching to *average* rather than maximum brightness as a primary performance criterion for fluorescent luminaires. If it is felt that at least some reference should be made to maximum brightness, it is suggested that it be expressed in the form of a ratio to the average and that a standard form of measurement be specified for all laboratories to follow without variation. Such a step would place the emphasis on the more reliable average brightness where it belongs and would permit better correlation between photometric data and glare evaluation systems. At the same time the ratio of maximum to average brightness would disclose any "hot spots" and would, therefore, make the system suitable for all luminaires including incandescent. If the mass of data that would thereby be accumulated after a period of time proved that the ratio of maximum to average brightness is never excessive, the requirement that the ratio be shown on photometric reports could be dropped forthwith.

DISCUSSION

WARD HARRISON*: I am much pleased to see this paper. Mr. Neidhart makes a very good case for average rather than maximum brightness ratings based largely on the inaccuracy of most data which purport to represent the latter.

I believe an equally strong case can be made on the basis that average brightness in most cases leads to a more intelligent appraisal of how the luminaires rates as to glare or lack of glare than does maximum brightness. Let us visualize, for example, a 12" globe with an absolutely uniform brightness of 1000 footlamberts. If this is seen against a background of say 10 footlamberts, our dislike for its presence in the visual field will be due pretty largely to the brightness of the periphery of the globe; in fact, due to contrast it will seem to be actually brighter than the center. If the brightness of the globe grades up let us say from 700 footlamberts at the periphery to perhaps 1400 in the central portion, it will appear to be more uniform than before and will be considerably more comfortable. Fortunately, most globes have this characteristic to a greater

*Consulting Engineer, Cleveland, Ohio.

or less extent, and we are certainly wrong if our system of appraisal penalizes them.

The case of the fluorescent lamp is somewhat different. If they were always seen against a comparably light background as in the case of tubes viewed lengthwise in RLM reflectors, the average brightness of the luminaire would always be preferable to a maximum brightness reading. On the other hand, when they are viewed sidewise just below the bottom edge of the reflector, contrast is very severe. Some method should, therefore, be used to penalize the luminaire.

SYLVESTER K. GUTH*: Ever since the illuminating engineer has been aware of the importance of visual comfort efforts were made to appraise the brightnesses of lighting equipments to insure that reasonably tolerable limits were not exceeded. Maximum brightness proved to be a useful yardstick for evaluating certain types of incandescent luminaires such as open bottom units on which the extremely high brightnesses of the filaments or bare bulbs could be seen. However, it seems to me that it is a value that has little application to the rating of the types of lighting equipments in general use today.

Since initiating our extensive BCD investigations, I have become more and more impressed by the importance of average brightness. The occupant of a room seldom is aware of the maximum brightness of a luminaire, unless he is viewing the source directly and from a relatively short distance. Most luminaires have a considerable brightness gradient which tends to blend the small areas of higher brightness into an effective larger luminous area. Thus, the light sources themselves are not viewed against dark backgrounds (at least not if recommended practice is followed) as was the case with many older types of equipments. If the maximum brightness includes an appreciable part of the total area of a unit, it automatically increases the average brightness by a considerable amount. Similarly, an exceptionally high maximum brightness of even relatively small areas is reflected in the average brightness.

There is, however, one important point yet to be established — the ratio or other relationships between the maximum and average brightnesses of luminaires, including the relative areas of each. This may be important for filament lamp units where the ratios can be considerably in excess of those obtained with fluorescent units. Thus, some additional research is needed with non-uniform luminous areas to determine some of the limitations involved.

There seems to be an international feeling in favor of average brightness. This problem was discussed at the recent meeting of the C.I.E. The British and Dutch investigators agreed that average brightness is more significant than maximum brightness for evaluations of visual comfort and discomfort.

PHELPS MEAKER*: I find myself in the perplexing position of belonging to both groups mentioned in Mr. Neidhart's opening paragraphs. The Committee on Testing Procedures for Illumination Characteristics is expected to describe traditional maximum brightness measurements in its testing guides. As a proponent of Glare Factors, I use average brightness almost exclusively, and have found no way of applying maximum brightness values in appraisals of glare and comfort.

One of the testing guides now under discussion by our committee will include filament type diffusing enclosing globes. Testing of this type of glassware, so important for so many years, has given us a heritage of several photometric procedures to which we tend to cling stubbornly. What is more logical than to prepare an opaque curtain with a one-inch square hole in it; hold the cloth up to a globe and measure the candlepower coming through the hole? And you will say, "Ha! In a diffusing globe that reading will be almost the same as average brightness."

So we continue reading the footlamberts or cd./sq. in. of the region including the brightest spot; simply because the brightest spot is the easiest to specify. But a maximum brightness value on a fluorescent fixture tells us nothing whatsoever about the extent of the bright region: its potency as a source of discomfort.

When a lighting man enters a room, you can tell immediately where his interest lies. He looks up at the luminaires, instead of appraising the appearance of the room from the standpoint of the habitual occupants. If the luminaires have little areas of high brightness, he shudders, without giving a thought as to whether these little sparkle points are a significant feature of the visual environment to the seated worker; except as they may add to the impression of brightness of the luminaire mass as a whole: its average brightness.

There is one class of office occupant who may have an interest in the brightness of small areas. He is the man who throws himself back in his chair, with feet up, and stares at the ceiling. To this man, the pattern of brightness visible may either provide an interesting scene of pleasing contrasts, or impress him with nakedness and lack of finesse in luminaire construction. His reaction should control his preference and choice of luminaire type, without reference to finite maximum brightness values.

The school child whose attention wanders from the teacher at the chalkboard, or from the monotony of black marks on white paper, may entertain himself by studying the brightness pattern overhead. I have heard no evidence that there is any harm in looking at things having in such generous degrees all the attributes of high visibility. Perhaps the gaze of such a child returns to his book brightness with momentarily impaired acuity, which may persist even for the period that it takes for the scenes of his day dreams to fade away. Looking at the matter open mindedly, has anything taken place more harmful than when the pupil looks out the window into a sunlit landscape?

I believe we should examine very critically the notion that our eyes are attracted, like insects, to a bright spot. Perhaps they are, but only for a glance sufficient to identify the thing. After that, I am convinced that we prefer to look at the interesting thing or area which presents a satisfying degree of visibility. Often this will not include the point of highest brightness; but if it does, it means that the illumination is so dim that nothing else in the overall scene is really visible to a comfortable degree.

Throughout the work with Glare Factors, we have been confronted with the problem of dealing with luminaire surfaces of differing brightness. Any attempt to evaluate small chinks of fluorescent lamps visible in the corners of a louver cell has revealed two striking differences between laboratory researches and the practical scene. (1) The small test glare sources in all of the basic studies except Petherbridge and Hopkinson's, were fixated on the line of sight, and were the *only features of the scene on which the eyes could fixate.* In the complete absence of competition, the glare source would have to occupy the entire visual attention. (2) Few if any of the researches have employed imme-

*General Electric Co., Cleveland, Ohio.

diate backgrounds for the glare sources which simulate luminaire brightness, itself interesting, of finite extent, and differing sharply from the field adaptation brightness.

Before deciding that it is satisfactory to consider average brightness, and ignore the "hot spots," we apply the following test: while looking normally about the room, can you describe the brightness variations in the luminaire before you — can you swear how many lamps it contains, etc. In the ordinary case, an answer is that one is aware only of a sensation of a mass hanging there, giving an impression of an order of orightness which can be expressed only as *the average*. You may then ask about the distant fixture which is only a few degrees from the line of vision. My experience here is that details are too small in visual angle, or that irradiation plays too strong a part for one to be able to say he is aware of more than average brightness.

The importance of this subject is so great that researches on the influence of immediate background brightness, as differing from field adaptation brightness, must be made before we can evaluate completely either the case for average brightness, or even discomfort glare itself.

When such additional knowledge is available, it will be feasible to draw some lines as to where we may not rely entirely upon average brightness. Obviously, very sharp brightness gradients, or sharply outlined masses of brightness differing by factors somewhere in the range five to one may not be lumped together under the single term "average brightness."

With regard to brightnesses effective in producing specular reflections, Mr. Neidhart has mentioned that the lamp brightness may exceed the rated value in open air. For all practical purposes, however, rated brightness, associated with the average brightness as the relieving surround, will give a sufficient working idea of the nature of the images to be expected.

I hope that these remarks may lead others to examine their inner convictions. For the moment, discard traditional approaches, discard a convenient competitive crutch (or headache), and just try to convince yourself whether maximum brightness values outside the "reflected glare zone" really give you the story about comfort and glare.

G. P. WAKEFIELD*: First, I would like to express my enthusiasm for luminaire brightness shown in a curve using polar coordinates. This, obviously, is the way to indicate brightness of a luminaire rather than in table form. It provides a quick, graphical means readily perceptible to everyone.

It might be too, too hopeful to expect luminaire manufacturers to adopt this device soon. A standard form and size might be suggested by an I.E.S. committee thus providing early standardization in a field which sincerely requires it. The use and practice of adhering to maximum brightness may be an accessory of the incandescent days. This figure undoubtedly served the purpose well, like the Harrison-Anderson coefficient of utilization method applied to narrow beam units.

When we refer to old methods, we certainly do not do so in disrespect, as they represented the best practice of the day. We could very well, though, be unfair to the Society and ourselves if we did not search all methods discerningly and constantly. We cannot afford to be satisfied. May I congratulate Mr. Neidhart in his attempt to clarify the luminaire brightness problem.

The use of integrated brightness may be mandatory in setting up brightness limitations for new, recommended practices. Certainly our committee will not use a brightness measurement that does not reflect today's version of an efficient seeing environment.

JOHN J. NEIDHART:* I wish to thank all of the discussors of my paper for their kind remarks and the support that they have given my proposal. It is hoped that this is an indication of possible early acceptance of average brightness as a primary performance criterion with maximum brightness data relegated to a secondary role.

In the foregoing discussion and in personal discussions I have had with other interested lighting authorities, it is evident that the only shortcomings of average brightness data are also failings of the maximum brightness data that we now employ. For example, neither average nor maximum brightness data give any indication of extreme differences in brightness that may exist in some luminaires such as the sidewise-viewed, fluorescent, RLM reflector mentioned by Dr. Harrison. As both Messrs. Guth and Meaker indicate, additional research is needed to determine the significance of marked non-uniformity in the brightness of luminaire areas. This fact, however, in no way prevents us from switching to average brightness instead of maximum brightness as the first step on the road toward improved and more valid performance data.

Mr. Wakefield shares my hope that an I.E.S. committee will suggest a standard form and size for presenting average brightness data. I know of several ways in which such data could be added to the standard I.E.S. Lighting Equipment Engineering Data Sheet without omitting any data now included. I plan to submit my proposals to the interested committees in the near future for their consideration. My proposal will include a suggestion that in addition to the average brightness curves, the average brightness and the maximum to average brightness ratio be tabulated for all angles at which maximum brightness data was previously given. This data could be recorded in the space now utilized for maximum brightness data.

*F. W. Wakefield Brass Co., Vermilion, Ohio.

*Author.

For latest listing of the Sustaining Members of the

Illuminating Engineering Society, see pages 20A, 22A, 25A, 26A.

Light, Color, and Environment In Government Offices

By L. M. ENDRES

THE PURPOSE of this paper is to consider certain phases of the relationship between light, color, and environment in the newer Government offices. We all realize that there is a relationship between light and color as elements of environment, but in the past many of us may have failed to appreciate the full extent of that relationship and the dependence of one element upon the other in creating satisfactory conditions. The artist is keenly aware of the effect that changing light has upon his colors. He can work at his best only when the light is "right." The decorator also realizes that light sources will affect the appearance of colors in his work.

However, does the decorator realize that the colors he uses greatly affect the lighting provided by the illuminating engineer? The engineer has found that he must supply more sources of light in a dark colored room than in a light colored room to obtain a given level of illumination at the working plane. Does he know, however, that the addition of more light sources does not necessarily produce a good lighting job?

We will now give a few facts on the work which has been done in Government buildings to provide good seeing conditions in offices.

Conditions under which employees are required to work in Government offices have been improved in the last 10 years. We can remember the time when the clerk worked in an office with high ceilings, high windows, and sufficient space to allow him greater freedom of action in placing his desk near windows. However, with the increase of activities within the Government it has been necessary to allow less space to each employee and to use every inch of space to the best advantage. This rearrangement has crowded people together and has placed many of them away from the windows in areas where the natural light provides little illumination on the work. Also, the newer buildings are designed with lower ceilings and less window area requiring employees to depend more and more upon artificial light.

We have found that the levels of illumination which are required today are much higher than those used previously. The increase has resulted from the constant research in lighting which demonstrated that better and more work could be done under higher levels of illumination. However, the providing of these high levels of illumination has changed the thinking of designers in the preparation of layouts for offices. The art of lighting has progressed from a design where fixtures were installed in a haphazard manner to a design where each element of the lighting installation is carefully planned. Where high levels of illumination are used the lighting fixtures must be carefully designed to avoid transmitting excessive light into the workers' eyes.

We have found that many of the complaints of eyestrain in the past resulted from the very high brightness of the lighting fixtures against the darker surfaces in a room.

In order to reduce the overall brightness it was believed that the fixture should have no part which is brighter than three times the brightness of the ceiling. Many tests on actual installations in Government offices indicate that the maximum brightness on a light ceiling above a fixture will be around 100 footlamberts. We, therefore, believe that the maximum brightness on any part of a lighting fixture should be between 100 and 300 footlamberts to provide a brightness ratio which has been found to be satisfactory. Very few lighting fixtures on the open market are well enough designed to approach this figure.

Where good seeing conditions are important we have found that the semi-direct or luminous indirect fixtures give the best brightness ratio between the fixture and the ceiling. Fixtures having louvers on the bottoms can be used to advantage in offices where considerable dust is present in the air. However, if office machines are in use in the office, we have found that the fixtures must have the maximum shielding possible.

We believe from our tests that fluorescent fixtures hung in continuous rows give a much better installation than those hung on individual outlets. In relamping and cleaning fixtures considerable strain is imposed on the equipment. Where individual fixtures are hung they eventually become

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Author: Chief Electrical Section, Buildings Management Division, General Services Administration, Washington, D. C.

out of line and additional work is required to align them again after relamping and cleaning.

We must give thought to the colors and finishes of the paints which we use on the surfaces in offices. The ceilings should be painted a flat white, reflectance not less than 75 per cent, with a 60° specular gloss reflectance of 0-8 per cent.[1] This white should be carried to the picture mold or at least 12 inches below the ceiling to give a good reflection surface for the maximum light from the fixture. A white ceiling will give a greater return of light from a fixture and will permit the advantageous use of the natural light which enters the room through the window. Tests undertaken in many offices indicate that the lighting levels on the working plane can be increased 25 per cent by painting the ceilings. The common use of glossy paints has done more to spoil good working conditions than any other item in offices since excessive amounts of light have been reflected into the workers' eyes. The walls should be painted in light colors having a reflectance of 50 to 60 per cent or a Munsell value of between 7 and 8. The 60° specular gloss reflectance of the finish should be between 15 and 30 per cent. Munsell hues of colors which have been found to be very satisfactory in offices are the yellows, yellow reds, green yellows, greens, and blue greens, which are warm colors. The Munsell chromas should not be greater than 4 and preferably 1 or 2. The windows and trims should be painted the same color as the walls with a semi-gloss finish having a 60° specular gloss reflectance of 20 to 40 per cent. The following colors have been developed by intensive experimentation and will provide a good working environment:

Green	5GY-8/2
Buff	7.5YR-8/4
Gray	10YR-7.5/1
Blue Green	5BG-8/1.5

These colors are given in Munsell notations. They specify hue, value, and chroma, in that order, as H-V/C. The "value" in Munsell notation is a measure of the reflectance. As a rough check the per cent reflectance is approximately equal to the square of the value. Thus, the reflectance of the green surface described above would be about 65 per cent; a value of 6 would have about a 35 per cent reflectance.

The doors, baseboards, and dado (if required) should be painted in the same Munsell hues and chromas as the walls with a value between 1 and 2 points lower. This change in value will give a pleasing effect and yet is not too distractive. However, if a punch of color is desired, the doors can be painted a contrasting color. The finish of the paint will give better washability if the 60° specular gloss reflectance is 20 to 40 per cent.

The floors should be covered with a material having a reflectance of 20 to 30 per cent. The color of this covering can be either similar or contrasting to the wall color.

Tests have indicated that the efficiency of the lighting in an office increased from 9 to 25 per cent by painting, cleaning of fixtures, replacement of lamps and replacement of floor covering. The efficiency of the lighting was determined by obtain-

1. Gloss is defined as the per cent of the total reflected light which is reflected specularly when the surface is illuminated at an angle of 60° from the perpendicular. See "Permanent Gloss Standards," ILLUMINATING ENGINEERING, February 1950, page 101.

Figure 1. (left) Conditions existing for card punch operation before the start of the test on "Influence of Lighting, Eyesight, and Environment Upon Work Production." Brightness ratio in the operators' normal field of view was around 100 to 1; illumination level about 11 ft-c.

Figure 2 (right) View of same area as shown in Figure 1, after relighting, painting of machines, and recovering of the floors. Brightness ratio is 8 to 1: illumination level 53 ft-c.

Figure 3. (left) Card punch machine before repainting.
Figure 4. (right) Card punch machine after painting and under new lighting.

ing an average footcandle reading on the working plane and multiplying this value by the area and dividing by the total lumens of all lamps in the fixtures. This method of determining the efficiency of an installation has been of value in indicating the results obtained.

Now that we have increased the level of illumination we must be sure that the furniture is light colored to reduce brightness ratios in the workers' field of view. Desks should have a working surface which has a reflectance of at least 35 per cent. Thus the employee who is working on paper having a reflectance of 60 to 70 per cent will not have any brightness ratio greater than 3 to 1 in his line of vision. File cabinets, tables, bookcases, and chairs should also be light in color. By proper handling of the equipment in an office the maximum overall brightness ratio can be held to less than 10 to 1.

In our report on a test in a card punch operation in the Internal Revenue Building published in a pamphlet entitled "The Influence of Lighting, Eyesight, and Environment Upon Work Production," it was found that under the conditions existing in the space before the start of the test the brightness ratio in the operators' normal field of view was around 100 to 1. This condition is shown by Fig. 1. After fluorescent fixtures had been installed giving a high level of illumination the brightness ratio dropped to 42 to 1 but when the walls, ceiling, and machines were painted in light colors and the floor had been covered with light colored linoleum the brightness ratio dropped to 8 to 1. This condition

Figure 5. (left) View of Census Bureau card punch office before repainting and relighting. Brightness ratios are 100 to 1; illumination level 11 ft-c.

Figure 6. (right) Census Bureau card punch office after repainting, but before the installation of new lighting. Brightness ratios were now 21 to 1; illumination level 30 ft-c.

Figure 7. Census Bureau card punch office after the addition of fluorescent luminaires. Brightness ratios were further reduced to 13 to 1; illumination level increased to 43 ft-c.

is shown in Fig. 2. Under the original conditions the average footcandle readings were 11. An average of 42 footcandles was obtained with the installation of fluorescent lighting fixtures. After the repainting had been completed the average footcandles increased to 53. The increase in the work production was found to be 5.5 per cent. We do not believe that the working conditions were satisfactory under the 42 footcandles, after the installation of fluorescent lighting fixtures but before repainting, because of the excessive brightness ratios in the operators' field of view.

Fig. 3 indicates the card punch machine before it was repainted. As you will see the seeing conditions at the task were not satisfactory since the worker was experiencing high brightness ratios between the work and the surroundings. Fig. 4 shows the conditions after the repainting and relighting. As you will note the seeing conditions are now excellent.

Another test was run in a card punch operation in the Census Bureau. The brightness ratio under the conditions found at the beginning of the test using incandescent lighting was 100 to 1 with average footcandles of 11. This condition is shown in Fig. 5. The efficiency of the lighting was 9 per cent. After repainting the space the brightness ratio was reduced to 21 to 1 and the footcandles increased to 30. This condition is shown in Fig. 6. The efficiency of the lighting increased to 25 per cent. With fluorescent luminaires and repainting the footcandles increased to 43 and the brightness ratio was reduced to 13 to 1. The efficiency of the lighting was 26 per cent. This condition is shown in Fig. 7.

You may be interested in some of the details of this test. The space was lighted by totally indirect incandescent lighting fixtures on 10-foot centers with 500-watt lamps. The ceiling was covered with acoustical material which had become very dark due to age and dust. A part of the space in which 36 operators were working was divided into three test zones by the erection of temporary partitions. In zone 1 no changes were made in the conditions of the lighting, painting, or equipment. In zone 2 the luminaires were cleaned, new lamps were installed in the fixtures, the walls and ceilings were painted, new floor covering was installed, and the machines were painted. The colors of paint were selected to be harmonious in combination and were light in shade. Zone 3 was similar to zone 2 except that three rows of two-lamp luminous indirect fluorescent fixtures with plastic reflectors were installed in a 20-foot bay. The lamps were 40-watt 4500 degree white.

Nine card punch operators, selected at random from the 36 operators in the space under test, were rotated among three machines in each zone. Each operator worked at each machine for one week and records of production were tabulated. This test showed a 3½ per cent increase in work production between zone 1 and zone 3.

These tests indicate that the environment of the worker is very important in providing an increase in work production. We have found that the brightness ratios are too high under all types of lighting unless color conditioning is provided. We believe that these tests indicate that high levels of illumination should not be used without providing high reflectance on the working surfaces to reduce brightness ratios.

Loss of Visibility Due to Reflections of Bright Areas

By H. M. SHARP
J. F. PARSONS

REFLECTED GLARE is a concise term which conveys a general meaning. It deals with the specular reflection of some luminous area by some object which the eye is attempting to see. The image may be so bright as to be annoying or even painful. More often, the image serves to reduce the contrast between the object and its background. This reduces the visibility of the object and makes it more difficult to see.

Reflected glare has always been a consideration in lighting design. When using the fluorescent lamp, lower in brightness and larger in area than the incandescent lamp, many of the obvious manifestations disappear. There has been a regrettable tendency, therefore, to consider that the difficulty has resolved itself. It has not, for the simple reason that any fluorescent lighted interior presents a large number of light sources to be specularly reflected.

Spencer[1] has stated the case very well. "It is reflected glare which is so troublesome to the worker. That this is not a mere figment of the imagination is shown by the records of ophthalmologists who have encountered thousands of cases of eye complaints covering fluorescent lighting. Some have even blamed the u-v of the lamp. The fact seems to be, however, that the trouble is not caused by u-v nor is it eliminated by louvering; it is caused by specular reflections of the lamps in the work and other objects which are in the normal field of view of the worker."

Mowry[2] and Spencer make this pertinent observation: "There is no other deficit in a lighting system that is as harmful and insidious (as reflected glare). Images of fluorescent lamps reflected on desk tops, typewriter keys, computation machines and glossy paper constitute a continual annoyance. This factor is not noticed when glancing in the doorway to appraise the lighting installation, but it becomes painfully evident to the worker after long hours of difficult visual toil."

Commendable progress has been made in the direction of utilizing dull finished or matte surfaces in the visual field. Generally speaking, such surfaces will not reflect a specular image. Again, there is a tendency to consider the difficulty resolved when such surfaces are provided.

In highly organized productive civilizations, producing and interpreting printed or written characters on a paper background represents a considerable portion of the visual work performed by individuals. Regardless of the texture of the background, the printed or hand lettered characters possess a certain amount of specular reflectance. They act as tiny mirrors. When they reflect an image of a bright area to the eye, they tend to approach or even exceed the brightness of their background. They thus lose contrast, and hence visibility. Under these circumstances the illumination provided tends to defeat its own purpose.

A simple test will disclose this. Place a printed page on a horizontal surface. Measure the footcandles there. Now tilt the page toward you and observe the printing to note if it becomes blacker or more distinct. If it does you have improved contrast by reducing or eliminating a specularly reflected image. If the footcandles are now measured at that position they will be found to be less than at the first position. Thus fewer footcandles without specular reflections will produce higher visibility. The difference in footcandles is a ready indication of the waste caused by "reflected glare."

No better explanation of a basic fundamental of vision can be quoted than that of Ferree[3] and Rand. "Diffuse reflection alone is serviceable to vision. The eye sees its object in the working plane only by light diffusely reflected from that plane. The light specularly reflected is either entirely wasted, not entering the eye at all, or worse than that is directly harmful to vision.

"When a specular image is reflected an image is formed of the source, not of the reflecting surface. When viewing a surface from which both kinds of reflection occur the eye focuses for the diffuse, not the specular reflection. The result is an image of the surface overlaid and blurred by a partially focused image of the source."

Only a small amount of quantitative data are available to aid in establishing guideposts for de-

Authors: Consulting Engineer, 82 Smallwood Drive, Snyder 21, N. Y., and Illuminating Engineer, Niagara Mohawk Power Corp., Buffalo 3, N. Y., respectively.

TABLE I.—Contrast and Visibility Factor.

Assumed conditions are a uniformly luminous area of 200 ft-L and a single line source of 1200 ft-L reflected in the work under general illumination of 30-ft-c and 50 ft-c.

		30 Footcandles				50 Footcandles			
		Contrast		Vis. Factor		Contrast		Vis. Factor	
	Dull Papers	**1200**	**200**	**1200**	**200**	**1200**	**200**	**1200**	**200**
1	Newsprint	.79	.90	.76	.79	.86	.92	.83	.85
2	16 lb Sulphate Bond	.82	.91	.76	.79	.86	.92	.83	.85
3	25 lb Rag	.83	.93	.78	.82	.87	.94	.84	.87
4	70 lb Offset	.85	.93	.79	.82	.88	.93	.84	.86
5	20 lb Hammermill	.84	.93	.78	.82	.88	.93	.84	.86
6	Canary Sulphate	.80	.92	.77	.80	.87	.93	.83	.86
7	24 lb 75% Rag	.70	.92	.74	.82	.80	.94	.82	.88
8	Warren Printone 60 lb Letter Press	.78	.92	.78	.81	.81	.94	.84	.87
9	Warren Silkote 60 lb Offset					.84	.94	.85	.87
10	Warren Cumberland 50 lb	.83	.93	.79	.82	.87	.94	.86	.88
11	Oxford 50 lb	.87	.94	.80	.82	.90	.94	.86	.87
12	Hopper 60 lb Offset	.77	.93	.76	.82	.84	.94	.85	.88
	Satin Finish & Semi-Gloss								
13	80 lb Gloss	.74	.92	.76	.82	.82	.94	.83	.88
14	50 lb Semi-Gloss	.74	.91	.75	.81	.82	.92	.82	.87
15	Oxford Polar Superfine 70 lb	.65	.91	.73	.82	.76	.93	.83	.88
16	Oxford Publication Text 50 lb	.66	.91	.74	.81	.77	.93	.81	.87
17	Oxford Engravatone 55 lb	.65	.91	.74	.81	.76	.94	.81	.87
18	Consolidated 50 lb	.73	.92	.76	.82	.81	.94	.84	.88
19	60 lb Semi-Gloss	.65	.91	.73	.81	.77	.93	.82	.87
20	St. Regis Flash Gloss	.58	.89	.70	.81	.71	.92	.80	.86
21	New York & Pennsylvania 50 lb Super	.60	.89	.71	.80	.73	.92	.82	.87
22	Consolidated Merrill 40 lb	.43	.87	.63	.80	.62	.91	.76	.87
	High Gloss								
23	Warrens 70 lb Lustro-Gloss	.72	.91	.76	.81	.79	.93	.83	.88
24	Warrens Lusterkote	.69	.86	.75	.80	.76	.93	.82	.88
		Average		.75	.81	Average		.83	.87

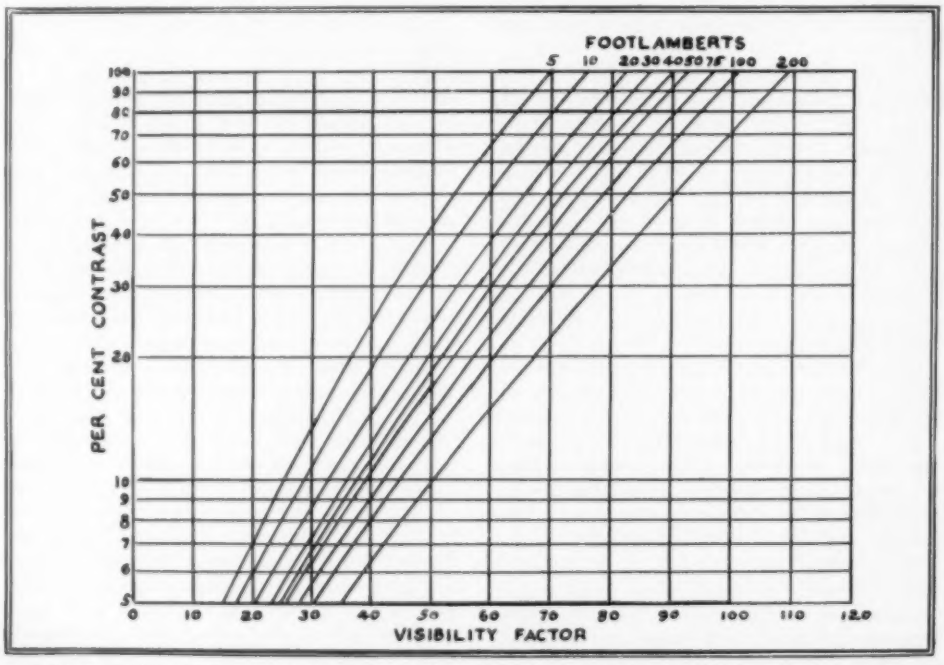


Figure 1. The relationship between brightness and brightness contrast used to determine Visibility Factors. See "Science of Seeing," D. Van Nostrand Co., New York, 1937, p. 127.

sign. Darley[4] has said, "The problem of reflected glare is present with fluorescent systems having relatively high brightnesses exposed to the work, even when the units are well shielded in the direct glare zone. Below 30 footcandles, reflected glare with the lamps 'seen by the work' is noticeable enough to be quite objectionable. From 30 to 50 footcandles, the effect is still not too good. Above 50 footcandles the effect is reasonably satisfactory but is not entirely eliminated."

In this study the authors have computed the contrast and visibility factors for printed letters on 24 commonly encountered paper stocks.[5] Two illumination levels were selected, 50 footcandles and 30 footcandles as representing values currently recommended for offices and schools. Two "glare source" brightnesses were assumed. One of 1200 footlamberts is representative of a "low brightness" fluorescent lamp shielded within an open bottom troffer. The other of 200 footlamberts is representative of the brightness of a large overhead area such as an indirectly lighted, or self luminous, ceiling.

The contrast was computed by the method outlined by Crouch.[6]

$$\text{Contrast} = \frac{(B_D + B_S) - (O_D + O_S)}{(B_D + B_S)}$$

where B_D = diffuse brightness of paper
B_S = specular brightness of paper
O_D = diffuse brightness of ink
O_S = specular brightness of ink

The visibility factor was computed according to the data presented by Darley and Ickis.[7] The curves of Fig. 1 are reproduced from Fig. 4 of their paper.

The computed results are listed in Table I. A number of interesting conclusions can be drawn from these data.

As to be expected it was found that for all 24 papers under the same lighting system, visibility factors increased with increase in illumination from 30 ft-c to 50 ft-c. However, approximately the same increase in visibility factor was found by changing from 30 ft-c of troffer lighting to 30 ft-c of overall ceiling lighting.

With 12 of the papers the visibility was practically the same under 30 ft-c of overall ceiling lighting as with 50 ft-c of troffer lighting.

Taking an average of all the papers it was found that under the troffer system an increase from the 30 ft-c to the 50 ft-c level raised the visibility factor 8 percentage points. Changing from 30 ft-c of troffer lighting to 30 ft-c of overall ceiling lighting raised the visibility factor by 6 points. *In other words by decreasing the light source brightness toward the work from 1200 ft-L to 200 ft-L an improvement in visibility occurs which is comparable to increasing the illumination by almost 50 per cent!*

This conclusion is of great economic significance to the users of light, and a challenge to the designers of lighting systems.

References

1. Spencer, D. E., Buck, William H., and Wolfson, Arnold A.: "The Fallacy of the Louverall Ceiling," ILLUMINATING ENGINEERING, Vol. XLIV, No. 3, p. 169 (March 1949).
2. Mowry, W. S., and Spencer, D. E.: *Electric Light and Power*, September 1948.
3. Feree, C. E., and Rand, G. F.: "The Ocular Principles in Lighting," *Transactions of the Illuminating Engineering Society*, Vol. XX, No. 3, p. 270 (March 1925).
4. Darley, W. G.: "An Analysis of Reflected Glare," ILLUMINATING ENGINEERING, Vol. XLIII, No. 1, p. 85 (January 1948).
5. Sharp, H. M., and Parsons, F.: "Specular and Diffuse Reflectances of Printing Ink and Common Papers," ILLUMINATING ENGINEERING, Vol. XLVI, No. 8, p. 413 (August 1951).
6. Crouch, C. L.: "Illumination and Vision," *Transactions of the Illuminating Engineering Society*, Vol. XL, p. 747 (November 1945).
7. Darley, W. G., and Ickis, L. C.: "Lighting and Seeing in the Drafting Room," *Transactions of the Illuminating Engineering Society*, Vol. XXXVI, No. 12, p. 1462 (December 1941).

For Discussors of I.E.S. Conference Papers

Are you planning discussion on any of the "Conference Papers" for publication with the paper in ILLUMINATING ENGINEERING? If so, be sure to submit it early to ensure its making the deadline. Copies of discussion should be distributed in this manner.

One copy (original) to Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

One copy to author for his rebuttal.

One copy to Hoyt P. Steele, Benjamin Electric Mfg. Co., Des Plaines, Illinois.

Yuletide Highlights

Christmas tree (above left) is, basically, a half-circle pedestal. Green 15-watt fluorescent lamp runs up back of tree. Chicken wire has been formed into cone shape and ribbons, trimmings, tiny ornaments and tinsel trim the tree, topped off with a big red bow. The ballast is mounted in the hollow of the tree shielded by the chicken wire. Similar effects could be obtained with a 40- or 60-watt incandescent lamp.

A rainbow effect of colored light (above) shines through the angel hair (spun glass) from a string of Christmas tree lamps buried in it around the base of the candle. Spray of bells is a regular commercial product.

A buffet setting (left) which is entirely handmade. The bases of the Christmas trees and center piece are made of wooden pedestals with porcelain sockets mounted on them. The 15-watt lamps are shielded by cone-shaped plastic material. Holes have been punched in the plastic and ribbon woven through for a decorative effect. Center pedestal throws light around the mirror surface, which is trimmed with a cotton "Greetings" pasted on. Wax candle figurines stand on centerpiece.

A Christmas tree shape (below) has been cut from plywood, and live greens attached for this door display. The tree is decorated with lights and ornaments and the entire doorway floodlighted by a projector floodlamp (not visible in photograph).

Seven-light graduated candles (below) with plastic halos light the windows. Around the doorway is strung regular outdoor Christmas tree strings interlaced with laurel roping. Giant Cellophane candles flank the door. In addition to projector spotlamps in the base of each candle a spot is placed, for emphasis, at the left side of the step.

Photos and data supplied by Myrtle Fahsbender, Director of Residential Lighting, Westinghouse Lamp Division, Bloomfield, N. J.

Current Recommended Practice for Sports Lighting—Part I

Prepared by the Committee on Sports and Recreational Area Lighting of the Illuminating Engineering Society*

Foreword

This report is the result of a four-year study of current practice and existing recommendations and standards in the sports lighting field. Since the layouts do not represent all that might be considered acceptable they are labeled "typical" to denote that others may be satisfactory.

I.E.S. Sports and Recreational Area Lighting Committee

R. J. Swackhamer, *Chairman*

A. H. Clarke, *Vice-Chairman*

J. W. Bateman	H. F. Ilgner
B. S. Benson, Jr.	F. R. Jeffrey
E. D. Benson	M. E. Keck
H. E. Carney	J. W. Lee
R. T. Dorsey	K. M. Reid
J. G. Felton	M. W. Ross
A. B. Hallaway	D. W. Rowten

D. E. Trefry

1. Introduction

1.1—*General*—(a) The past decade has witnessed an unparalleled growth in sports and recreational lighting. Ten years ago only two major league baseball fields were lighted; today only one major league park remains unlighted. During the same period the number of lighted football fields has quadrupled, and softball diamonds lighted for night play have multiplied six times. Today, boxing, bowling, badminton—practically all sports and recreations—may be so illuminated that player and spectator requirements are satisfied.

(b) The lighting of areas used for various sports activities especially those located outdoors involves problems not encountered in other fields of lighting. Many of these problems including, for example selection of proper floodlight locations, aiming techniques, and provision for multiple uses of the area and lighting facilities have not previously been covered by Illuminating Engineering Society recommended practices.

1.2—*Purpose*—The purposes of this report are (1) to present recommended footcandle levels satisfactory to players and spectators, (2) by typical layouts to indicate lighting systems which conform to current good practice, and (3) to aid in the evaluation of existing installations.

1.3—*Scope*—This recommended practice covers all forms of sports from the so-called major professional sports, such as baseball and football, to the recreational and playground sports, such as horseshoe pitching and croquet. It also includes recommendations for the lighting of gymnasiums and other interior areas specifically designed for sports activities such as squash, handball, and bowling.

2. Factors of Good Illumination

2.1—*Illumination Levels*—(a) It is important that levels of illumination be sufficient for comfortable and accurate seeing and to enable (1) the players to perform their visual task and (2) the spectators to follow the course of the play.

(b) In those sports where large numbers of spectators are expected, such as in large football and baseball stadiums, the illumination level is determined by the amount required for the spectators in the row of seats farthest removed from the playing area to follow the course of the play. This condition may require several times the amount of light found satisfactory for the players. The illumination levels suggested by Table I are those which are currently considered values of good practice taking into consideration both players and spectators.

(c) It is important to note that the illumination values in Table I are in most cases stated as *Average Horizontal Footcandles in Service*. It is recognized that the vertical component of the illumination on the playing area is important in most sports. Particularly in the "aerial" games, both players and spectators rely to a considerable degree on the vertical illumination on or near the playing area and in some cases well above the playing area. The same is true of movies and television, for the normal viewing position. In full recognition of the importance of *vertical* illumination, the recommended footcandle values for most sports and recreational areas are given for *horizontal* illumination for two reasons, (1) values of horizontal footcandles are much less complicated to compute and to measure in the field, and (2) the vertical components of illumination have been found adequate where the horizontal illumination meets the values in Table I and lighting equipment of the proper type (I.E.S. type distribution) is positioned at mounting heights and locations conforming to accepted good practice. Unless otherwise noted, the recommended values in this table are horizontal footcandles on the playing surface or for aerial sports are horizontal footcandles on a plane 36 inches above the ground or floor.

2.2—*Quality of Illumination*

2.2.1—*General*—The quality of lighting whether natural or artificial is highly important in providing good seeing conditions. Glare, uniformity, and direction are the most significant factors in determining the quality of illumination.

2.2.2—*Uniformity* — Reasonable uniformity of illumination over a playing area is required for satisfactory seeing by players and spectators. Expressed in terms of horizontal illumination, acceptable uniformity occurs when the ratio of maximum to minimum illumination does not exceed three to one for those sports in which play is skillful, or the visual task is severe, or there are likely to be spectators.

*Approved by the I.E.S. Council, December 1950.

TABLE I.—Current Illumination Recommendations.

	Average Horizontal Footcandles in Service*	
Archery	**Target**	**Shooting Line**
Tournament	10**	10
Recreational	5**	5
Badminton		
Tournament	30	
Club	20	
Recreational	10	
Baseball	**Infield**	**Outfield**
Major League	150	100
AA and AAA League	75	50
A and B League	50	30
C and D League	30	20
Semi-Pro & Municipal League	20	15
On seats during game	2	
On seats before and after game	5	
Basketball		
College and Professional	50	
College Intramural and High School with spectators	30	
College Intramural and High School without spectators	20	
Recreational (outdoor)	10	
	On land	**150' from shore**
Bathing Beaches	1	3**
Billiards	**On table**	
Tournament	50	
Recreational	30	
General Area	10	
Bowling	**Lanes**	**Pins**
Tournament	20	50**
Recreational	10	30**
Bowling on the Green		
Tournament	10	
Recreational	5	
Boxing or Wrestling		
Championship, Professional, Amateur — Ring	500 / 200 / 100	
Seats during bout	2	
Seats before and after bout	5	
Croquet		
Tournament	10	
Recreational	5	
Curling	**Tees**	**Rink**
Tournament	20	10
Recreational	10	5
Gymnasiums (Refer to individual sports listed separately)		
Exhibitions, Matches	30	
General Exercising and Recreation	20	
Assemblies	10	
Dances	5	
Lockers & Shower Rooms	10	
Handball		
Tournament	30	
Club	20	
Recreational	10	
Golf Driving		
General on the Tees	10	
At 200 Yards	3**	
Practice Putting Green	10	
Horse Shoes		
Tournament	10	
Recreational	5	
Ice Hockey		
College or Professional	50	
Amateur League	20	
Recreational	10	

	Average Horizontal Footcandles in Service*	
Football		
Index: †Distance from nearest side line to the farthest row of spectators		
Class		
I — Over 100'	100	
II — 50' to 100'	50	
III — 30' to 50'	30	
IV — Under 30'	20	
V — No fixed seating facilities	10	
†It is generally conceded that the distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered and the following ratio is suggested: Class I for over 30,000 spectators; Class II for 10,000 to 30,000; Class III for 5,000 to 10,000 and Class IV for under 5,000 spectators.		
Racing		
Bicycle	20	
Motor (Midget Auto or Motor Cycle)	20	
Horse	20	
Dog	20	
Rifle Ranges	**Outdoor**	**Indoor**
On Target	30**	50**
Firing Point	10	10
Range	—	5
Roque		
Tournament	20	
Recreational	10	
Shuffle Board		
Tournament	10	
Recreational	5	
Skating		
Roller Rink	5	
Ice Rink	5	
Lagoon, Pond or Flooded Area	1	
Ski Slope Practice	0.5	
Soccer		
Professional & College	30	
High School	20	
Athletic Field	10	
Skeet Shoot		
Target—Surface at 60'	30**	
Firing Point—General	10	
Squash		
Tournament	30	
Club	20	
Recreational	10	
Swimming Pools		
General—Overhead	10	
Underwater—Outdoors 3 watts per sq. ft. of surface		
Underwater—Indoors 5 watts per sq. ft. of surface		
Softball	**Infield**	**Outfield**
Professional & Championship	50	30
Semi-Pro	30	20
Industrial League	20	10
Recreational	10	5
Tennis	**Lawn**	**Table**
Tournament	30	50
Club	20	30
Recreational	10	20
Trap Shoot		
Target—at 150'	30**	
Firing Point—General	10	
Volley Ball		
Tournament	20	
Recreational	10	

*On the playing surface; for aerial sports on a plane 36 inches above the ground.
**Vertical.

2.2.3—*Luminaire Location* — **(a)** The effects of glare are diminished as the luminaires are removed from the normal line of sight of players and spectators. The angle between the luminaire and the normal line of sight is affected both by the luminaire location in a horizontal plane as well as by the mounting height.

(b) The typical layouts show luminaire locations which reflect balanced judgment with regard to providing light from the proper direction at the same time locating the luminaires out of the normal line of sight. Where physical obstructions require changes from these typical locations care must be taken to evaluate carefully the possible lines of sight of both players and spectators.

(c) Recommended mounting heights are also shown on the typical layouts. Where for physical or economic reasons, it is considered necessary to utilize lower mounting heights then the problems of possible glare must be carefully considered. For floodlighting applications the followng basis may be used to determine mounting heights which are minimum from the standpoint of glare: (1) the angle between the horizontal playing surface and a line drawn through the lowest mounted floodlight and a point ⅛ the distance across the playing area should not be less than 30 degrees, and (2) in addition to meeting the requirement above, the minimum mounting height should not be less than 20 feet for ground sports and 30 feet for aerial sports.

2.2.4—*Luminaire Brightness*—Glare is reduced by reducing the brightness of the luminaire.

2.2.4.1—*Indoor* — **(a)** In applications where fixed equipment is mounted on or near the ceiling this consideration involves two angular regions: (1) the angle from the vertical within which the lamps are not directly visible (called the shielded zone), and (2) the angle within which the lamps are visible (called the unshielded zone).

(b) Excessive brightness within the shielded zone may cause glare, particularly in large spaces. Brightness in the unshielded zone may cause direct glare, or glare by reflection in specular surfaces of bowling lanes, the surface of water in swimming pools, polished floors and walls. In addition the brightness of the luminaire in the unshielded zone may cause discomfort or even disability glare if players or spectators look upward. This possibility is minimized by so locating the luminaires that they are removed from the normal lines of sight as far as possible, and/or by using low brightness sources.

2.2.4.2—*Outdoor* — The brightness of floodlights, particularly narrow beam types, is lower as they are viewed at increasing angles to axis of the beam. For this reason, particular emphasis is placed on location and aiming so that, within practical limits, floodlights are not directed along the normal lines of sight of spectators or players.

2.3—***Surround Brightness***—**(a)** Increasing the brightness of the surround reduces contrast and improves visibility.

(b) One of the most effective ways to reduce the effects of glare is to keep the brightness of the surround to a reasonable level. This can be done very effectively for indoor sports by finishing the walls and ceiling of the rooms in light colors. Control of the surround brightness is much more difficult in outdoor locations; however, a great deal can be done in this regard. Adequate light in the stands and light colored fences, together with provisions for providing some illumination on the ground immediately around the playing field, aid considerably in improving the surround conditions.

2.4—***Direction of Light*** — **(a)** The eye sees by brightness contrast. The brightnes scontrast between an object and its surround as well as the brightness difference between the various surfaces of an object provide the contrast required to see. Since the visual tasks of the spectators and players involve seeing vertical surfaces as well as horizontal surfaces, it is essential to provide adequate illumination on both the horizontal surfaces and the vertical surfaces of a solid object. Since the objects of view in sports are not flat faced solids it is not essential to provide uniform illumination on all surfaces; in fact, semi-directional illumination produces shading which aids seeing by its modeling effect. Model studies (see Fig. 1) and stationary ball analyses are useful in determining proper pole locations, mounting heights and method of aiming floodlights.

(b) For unidirectional sports, such as bowling, racing, handball, archery, etc. it is desirable and possible to provide much higher vertical footcandles from one direction as well as locate the luminaires so that they are almost completely removed or shielded from the normal field of view.

(c) The aiming of the floodlights, even with correct luminaire locations and mounting heights, determines to a large extent whether the uniformity, direction and candlepower towards the eye are satisfactory. For information concerning the correct fundamentals of aiming floodlights see Appendix B.

3. Classification of Play

3.1—***Player Requirements*** — Player requirements vary with the class of play. *Tournament* classification applies to the caliber of play as found in tournaments and exhibitions. *Club* classification applies to good, fast play.

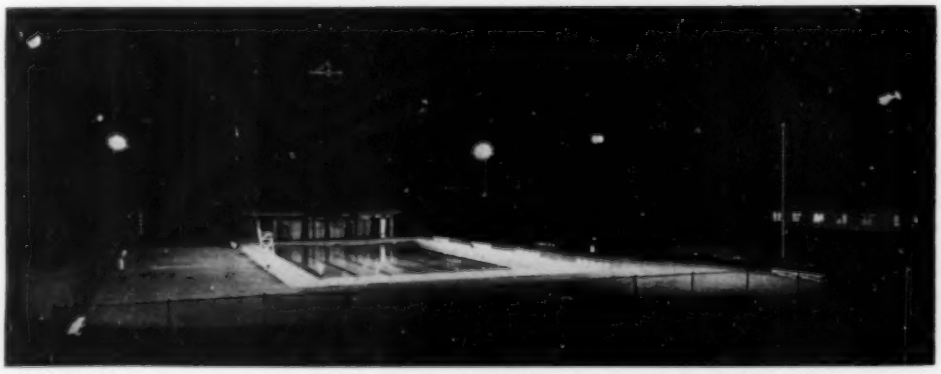
Figure 1. Models are often helpful in studying sports lighting designs.

BASEBALL Major league baseball park. See layout Figure 2.

FOOTBALL Football field illuminated by floodlights located on towers behind the stands. See layout Figure 4.

SKIING Illuminated ski slope. See layout Figure 24.

COMBINATION FIELD Combination baseball, softball and football field in a small community, illuminated to approximately 40 footcandles by 147 floodlights. See layouts Figures 6 and 7.



SWIMMING Swimming pool with overhead and underwater lighting. See layouts Figures 20 and 21.

TENNIS Two tennis courts illuminated by floodlights mounted on four poles. See layouts Figures 10, 11, 12.

BOWLING Bowling green. See layout Figure 31.

PLAYGROUND BASKETBALL Illumination of a playground basketball court. See layout Figure 9.

BOXING Outdoor boxing ring. See layout Figure 19.

GOLF Driving range illuminated by layout in Figure 15.

Recreational classification applies to play for fun and relaxation.

3.2—*Spectator Requirements*—Spectator requirements for satisfactory seeing vary with the type of sport, distance from and orientation to the playing field. A stadium where the last row of spectators is several hundred feet away from the playing area must be lighted to a high level of illumination if they are to follow the play. If the spectator section is limited to small bleachers along the sides of the field the illumination level which will provide good playing conditions will adequately serve the spectators.

4. Equipment Classification

4.1—*General*—(a) The optical characteristics of the luminaire affect to a large extent such important factors as direct and reflected glare, shadows, distribution and diffusion. Because there are wide variations in these optical characteristics the selection of the correct luminaire for a particular application deserves careful consideration.

(b) Luminaires should be designated so as to describe the manner in which the light from the lamp is controlled by the lighting unit, the degree of concentration of zonal lumens, and mechanical details. Since in sports and recreational area lighting there are both outdoor and indoor lighting problems the lighting equipment should necessarily be selected to qualify for the service designated. There are therefore separate designations and classifications pertaining to outdoor and indoor lighting equipment.

4.2—*Outdoor Floodlight Luminaire Designation*

4.2.1—*Floodlight Classes*—(a) HEAVY DUTY (HD). This class is weathertight,[1] having a substantially constructed housing into which is placed a separate and removable reflector. The assembly is enclosed by a cover glass.

(b) GENERAL PURPOSE (GP). This class is weathertight,[1] and so constructed that the housing forms the reflector surface. The assembly is enclosed by a cover glass. Reflectorized type lamps designed for outdoor use are considered to fall into this classification.

(c) OPEN (O). This class is weatherproof,[1] and so constructed that the housing forms the reflecting surface. No cover glass.

(d) OPEN WITH REFLECTOR INSERT (OI). This class is weatherproof,[1] and so constructed that the housing forms only part of the reflecting surface. An auxiliary reflector is used to modify the distribution of light. No cover glass.

4.2.2—*Beam Data*—The choice of the light distribution of a luminaire may be selected and designated by type as follows:

Luminaire Type	Beam Spread in Degrees
1	10° to less than 18°
2	18° to less than 29°
3	29° to less than 46°
4	46° to less than 70°
5	70° to less than 100°
6	100° and over

4.2.3—*Method of Designation*—Floodlights covered by these standards may be designated as Heavy Duty Type 1, 2, 3, etc., General Purpose Type 1, 2, 3, etc., and Open Type 4, 5, 6, etc.

4.2.4—*Performance Characteristics*—The suggested typical layouts for outdoor sports (pages ..... to .....) assume the use of floodlights having efficiencies which equal or exceed the Standards (NEMA) or Floodlight Performance listed in Appendix A.

4.2.5—*Photometric Data*—For the purpose of classifying floodlights the method of determining and recording the beam spread and beam efficiency should be in accordance with the adopted report of the I.E.S. Committee on Testing Procedure of Illumination Characteristics.[2]

4.3—*Interior Lighting Luminaire Designation*—(a) Interior lighting luminaires may be classed into five different types, based on the manner in which light is distributed from the luminaire. These classifications apply to luminaires with either filament or fluorescent sources. These types are convenient in describing the manner in which the light is distributed from the luminaires, and do not in themselves imply quality of lighting. The figures given below indicate the percentages of light emitted by the luminaire upward and downward:

Type (C.I.E. Classification)	Approx. Distribution of Light Emitted by Luminaire Upward	Downward
Direct	0 - 10%	100 - 90%
Semi-direct	10 - 40	90 - 60
General Diffuse	40 - 60	60 - 40
Semi-indirect	60 - 90	40 - 10
Indirect	90 - 100	10 - 0

(b) Direct luminaires may be further classified so as to denote concentration of zonal lumens such as concentrating, medium spread and wide spread.

4.3.1—*Method of Designation*—(a) Interior direct type lighting luminaires covered by these standards may be designated in accordance with the recommendations of the I.E.S. Committee on Illumination Performance Recommendations.[3]

(b) For the purpose of calculation in the design of the typical layouts the photometric performance of the luminaires is assumed to be approximately the value shown in Table 9-2 of the *I.E.S. Lighting Handbook*, Second Edition.[4]

4.3.2.—*Photometric Data*—The method of determining and recording photometric data should be in accordance with the adopted report of the I.E.S. Committee on Testing Procedure of Illumination Characteristics.[5, 6]

5. Typical Layouts Outdoors

5.1—*General*—(a) Illumination levels obtained with the typical layouts presented in this report may be expected to meet substantially the I.E.S. recommended footcandle values. In any installation, the illumination obtained is subject to unpredictable variations in installation, aiming, luminaires, lamps, voltage at the lamps and atmospheric transmission.

References

1. *American Standard Definitions of Electrical Terms*, American Institute of Electrical Engineers, New York City, 1942.

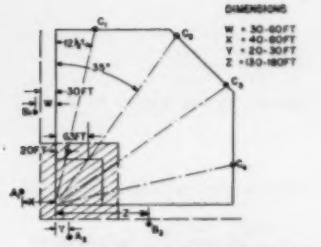
2. Committee on Testing Procedure for Illumination Characteristics of the I.E.S., Report of, "Specifications for Testing Lighting Equipment, Section 11, Specification No. F-2-1941, Incandescent Filament Floodlights," ILLUMINATING ENGINEERING, Vol. XXXI, No. 6 (June 1941).

3. Committee on Illumination Performance Recommendations of the I.E.S., Report of, "Recommended Practice for the Illumination Performance of Direct and Semi-Direct Luminaires," unpublished.

4. *I.E.S. Lighting Handbook*, Second Edition, Illuminating Engineering Society, New York, N. Y., 1951.

5. Committee on Testing Procedure for Illumination Characteristics of the I.E.S., Report of, "Guide for Photometric Testing of Fluorescent Luminaires," ILLUMINATING ENGINEERING, Vol. XLIV, No. 7 (July 1949).

6. Committee on Lighting Service of the I.E.S., Report of "Specifications for Testing Lighting Equipment, Section I, Specification No. C-1-1940, Luminaires for General Lighting," ILLUMINATING ENGINEERING, Vol. XXXV, No. 3 (March 1940).



THESE LAYOUTS ARE BASED ON THE FOLLOWING FOLLOWING:

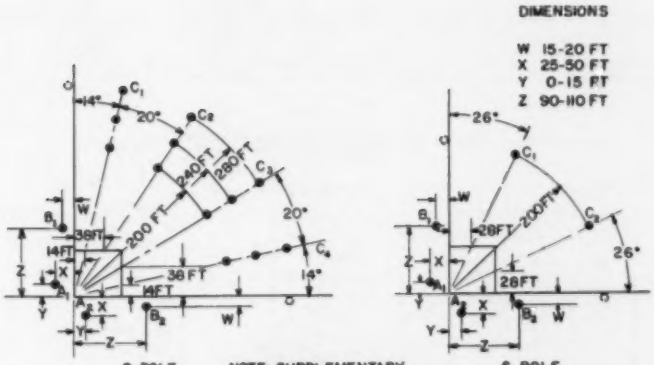
TOTAL PLAYING AREA, INCLUDING A STRIP 30 FT OUTSIDE OF EACH FOUL LINE	132,500 SQ FT
INFIELD AREA (SHADED)	22,500 SQ FT
OUTFIELD AREA	110,000 SQ FT

Class of Baseball	IES Current Recommended Practice—Footcandles Maintained in Service		Floodlights		Approx. No. per Pole			Minimum Mounting Height to Bottom Floodlight Crossarm (feet)
	Infield	Outfield	Class	Type	A	B	C	
Major League	150	100	GP	3, 4 or 5	100	200	100	120
AAA and AA	75	50	GP	3, 4 or 5	50	100	50	110
A and B	50	30	GP O or OI	3, 4 or 5 4, 5 or 6	32 44	64 88	32 44	90
C and D	30	20	GP O or OI	3, 4 or 5 4, 5 or 6	24 32	48 64	24 32	70
Semi-professional and Municipal	20	15	GP O or OI	3, 4 or 5 4, 5 or 6	16 22	32 44	16 22	70

LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.

Figure 2. Typical Layout for Baseball.

Figure 3. Typical Layout for Softball.



NOTE: SUPPLEMENTARY CORNER POLES (C) CARRY OVERHEAD WIRES AROUND BOUNDARY RATHER THAN ACROSS PLAYING AREA.

Class	IES Current Recommended Practice—Footcandles Maintained in Service		Outfield Size (feet)	Floodlights (Alternate Installations)									Minimum Mounting Height to Bottom Floodlight Crossarm (feet)	
				Types 3, 4 or 5 Class GP			Type 6 Class OI			Type 6 Class O				
				No. per Pole			No. per Pole			No. per Pole			A & B Poles	C Poles
	Infield	Outfield		A	B	C	A	B	C	A	B	C		
8 POLE LAYOUT														
Professional Championship	50	30	280	14	30	18	18	38	27	24	48	34	50	60
			240	14	20	13	18	30	16	24	32	22	50	55
Semi-Professional	30	20	280	8	18	14	10	28	18	14	32	22	40	55
			240	8	14	10	10	22	13	14	24	15	40	50
Industrial League	20	10	280	5	10	7	7	14	9	8	16	12	35	50
			240	5	7	5	7	10	6	8	14	8	35	45
			200	5	5	3	7	7	4	8	10	5	35	40
6 POLE LAYOUT														
Recreational	10	5	200	2	3	3	3	4	4	4	5	5	35	40

LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.
POLES: 6 for Recreational, 8 for other classes.

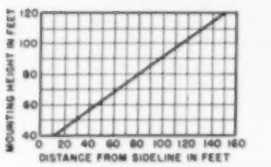


CHART SHOWING MINIMUM MOUNTING HEIGHT FROM FIELD TO BOTTOM FLOODLIGHT CROSSARM

ANY OF THE 6 POLE PLANS (AT RIGHT) - OR ANY INTERMEDIATE LONGITUDINAL SPACINGS - ARE CONSIDERED GOOD PRACTICE, WITH LOCAL FIELD CONDITIONS DICTATING THE EXACT POLE LOCATIONS.

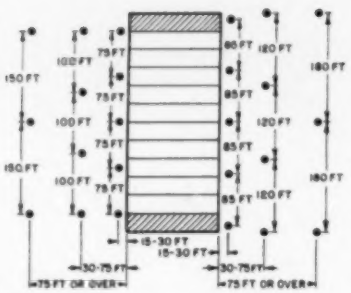


Figure 4. Typical Layout for Football.

Class	Distance—Nearest Sideline to Farthest Row of Spectators (feet)	Spectator Seating Capacity
I	Over 100	Over 30,000 spectators
II	50 - 100	10,000 - 30,000
III	30 - 50	5,000 - 10,000
IV	Under 30	5,000
V	No fixed seating facilities	

CLASSIFICATION

It is generally conceded that distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Distance—Nearest Sideline to Floodlight Poles (feet)	No. of Poles	Floodlights		
				Type	Class	No. per Pole
I	100	over 140	6	1 or 2	GP	90
		100 - 140	6	2 or 3	GP	80
II	50	75 - 100	6	3	GP	36
		50 - 75	8	3	GP	24
III	30	30 - 50	8	4	GP	16
IV	20	15 - 30	10	5	GP	8
		15 - 30	10	6	OI	12
		15 - 30	10	6	O	18
V	10	15 - 30	10	5	GP	4
		15 - 30	10	6	OI	6
		15 - 30	10	6	O	8

LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.

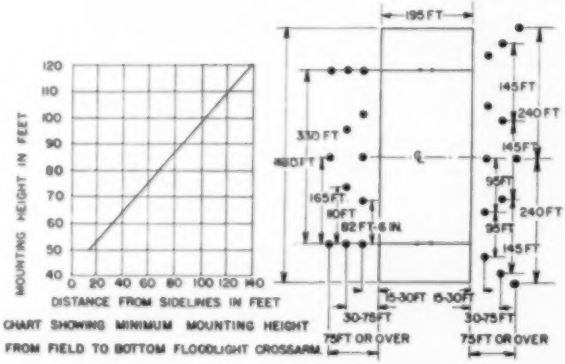


CHART SHOWING MINIMUM MOUNTING HEIGHT FROM FIELD TO BOTTOM FLOODLIGHT CROSSARM

ANY OF THE ABOVE SIX POLE PLANS OR ANY INTERMEDIATE LONGITUDINAL SPACINGS ARE CONSIDERED GOOD PRACTICE WITH LOCAL FIELD CONDITIONS DICTATING EXACT POLE LOCATIONS.

Figure 5. Typical Layout for Rugby Football.

Class	Distance—Nearest Sideline to Farthest Row of Spectators (feet)	Spectator Seating Capacity
I	Over 100	Over 30,000 spectators
II	50 - 100	10,000 - 30,000
III	30 - 50	5,000 - 10,000
IV	Under 30	5,000
V	No fixed seating facilities	

CLASSIFICATION

It is generally conceded that distance between the spectators and the play is the first consideration in determining the class and lighting requirements. However, the potential seating capacity of the stands should also be considered.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Distance—Nearest Sideline to Floodlight Poles (feet)	No. of Poles	Floodlights		
				Type	Class	No. per Pole
I	100	over 140	6	1 or 2	GP	120
		100 - 140	6	2 or 3	GP	106
II	50	75 - 100	6	3	GP	48
		50 - 75	8	3	GP	32
III	30	30 - 50	8	4	GP	21
IV	20	15 - 30	10	5	GP	11
		15 - 30	10	5 or 6	OI	16
		15 - 30	10	6	O	24
V	10	15 - 30	10	5	GP	5
		15 - 30	10	5 or 6	OI	8
		15 - 30	10	6	O	11

LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.

Class	IES Current Recommended Practice—Footcandles Maintained in Service		Floodlights				
	Infield	Outfield	Class	Type	Approx. No. per Pole A	B	C
Baseball (Semi-Pro)	20	15	GP or O or OI	3, 4 or 5	16	32	16
Football		15		4, 5 or 6	22	44	22

LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.
MOUNTING HEIGHT: 70 feet minimum.

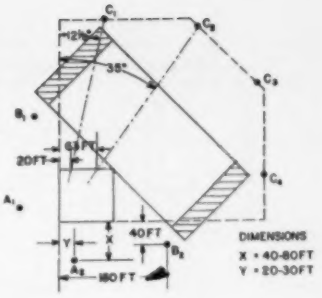
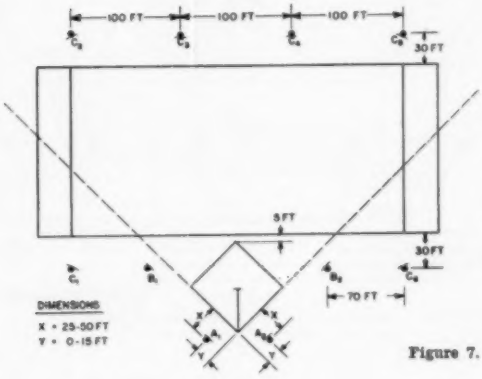


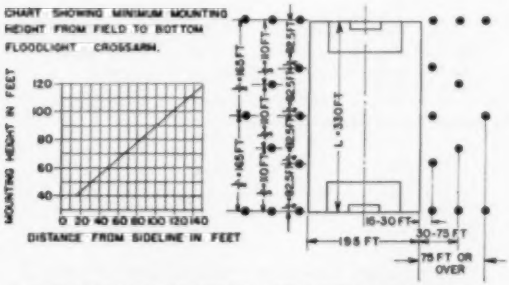
Figure 6. Typical Layout for Combination Baseball and Football.



Class	IES Current Recommended Practice—Footcandles Maintained in Service		Poles			Floodlights		
	Infield	Outfield	Location	No.	Mount. Height (feet)	Type	Class	No. per Pole
Softball (Industrial)	20	10	B & C	8	60	3, 4 or 5	GP	7
Football		10	A	2	40	3, 4 or 5	GP	4

LAMPS: 1500-watt clear general lighting service operated at 10% over-voltage.

Figure 7. Typical Layout for Combination Softball and Football.

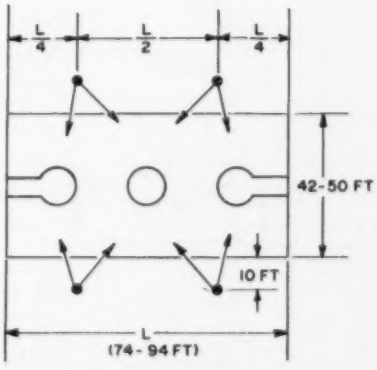


NOTE: THE NUMBER OF FLOODLIGHTS SHOWN BELOW IS BASED ON THE SIZE FIELD INDICATED ON DRAWING. ADJUST NUMBER OF FLOODLIGHTS AND POLE SPACING IN RATIO TO AREA FOR SMALLER OR LARGER FIELDS.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Distance—Nearest Sideline to Floodlight Poles (feet)	No. of Poles	Floodlights Type	Class	No. per Pole
Professional and College	30	over 140	6	1 or 2	GP	30
		100 - 140	6	2 or 3	GP	28
		75 - 100	6	3	GP	24
		50 - 75	8	3	GP	16
High School	20	30 - 50	8	4	GP	12
		15 - 30	10	5	GP	10
		15 - 30	10	5 or 6	OI	14
		15 - 30	10	6	O	20
Recreational	10	15 - 30	10	5	GP	6
		15 - 30	10	5 or 6	OI	8
		15 - 30	10	6	O	10

LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.

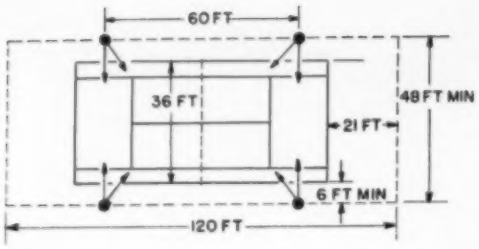
Figure 8. Typical Layout for Soccer Fields.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights Type	Class	No. per Pole
Recreational	10	5 or 6	GP	2
			O	3

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 30 feet above court.
POLES: 4.

Figure 9. Typical Layout for Outdoor Basketball Courts.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights: Type	Floodlights: Class	Floodlights: No. per Pole	Lamp Size (watts)
Recreational	10	5 or 6	GP	2	1000
			O	2	1500

LAMPS: General lighting service operated at rated voltage.
MOUNTING HEIGHT: 30 feet above court.
POLES: 4.

Figure 10. Typical Layout for Single Tennis Court—4 Poles.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights: Type	Floodlights: Class	Floodlights: No. per Pole X	Floodlights: No. per Pole Y
Club	20	5 or 6	GP	4	2
			O	5	3
Recreational	10	5 or 6	GP	2	1
			O	3	1

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 30 feet above courts.
POLES: 8.

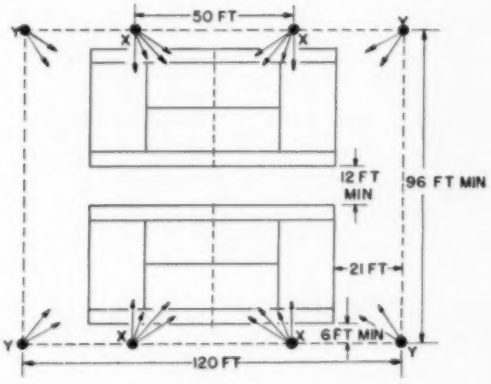
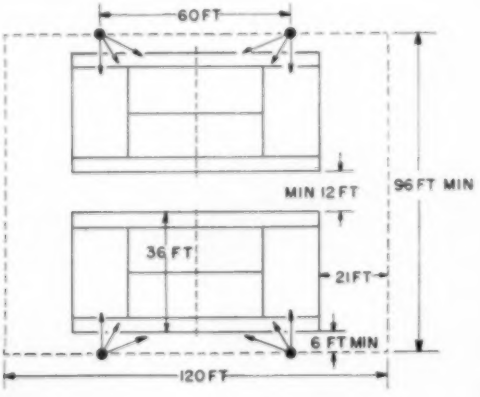


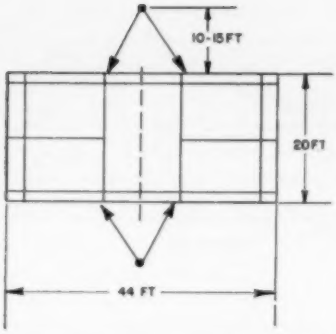
Figure 11. Typical Layout for Double Tennis Courts—8 Poles.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights: Type	Floodlights: Class	Floodlights: No. per Pole
Recreational	10	5 or 6	GP	3
			O	4

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 30 feet above court.
POLES: 4.

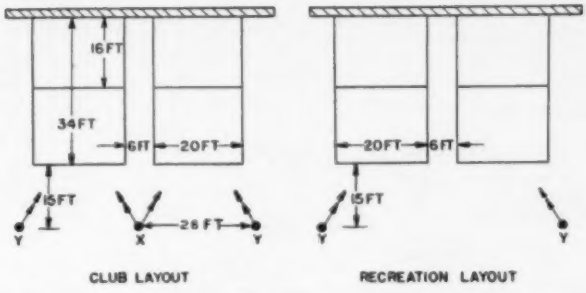
Figure 12. Typical Layout for Double Tennis Courts—4 Poles.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
		Type	Class	No. per Pole	Lamp Size
Recreational	10	5 or 6	GP O	2 2	750 1000

LAMPS: General lighting service operated at rated voltage.
MOUNTING HEIGHT: 20-25 feet above court.
POLES: 2.

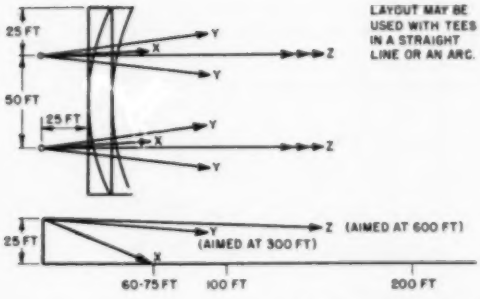
Figure 13. Typical Layout for Outdoor Badminton Courts.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights				
		Type	Class	No. per Pole X	No. per Pole Y	Lamp Size (watts)
Club	20	5 or 6	GP O	4 4	2 2	1000 1500
Recreational	10	5 or 6	GP O	*	4 4	1000 1500

*For recreational installations no "X" poles are required.
LAMPS: General lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 25 feet above ground.

Figure 14. Typical Layout for Outdoor Handball Courts.



IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
	Aiming Point	Type	Class	No. per Pole*
10—general on tees	X	5	GP	1
3 on vertical surface at 200 yards	Y	3	GP	2
	Z	1	GP	3

*The number of floodlights required are computed from above table using one pole for every 50 feet of range width.
LAMPS: X and Y—1500-watt clear general lighting service.
Z—1000-watt floodlight service (G-40) operated at rated voltage.

Figure 15. Typical Layout for Golf Driving Ranges.

IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		Watts per Square Foot of Area
	Type	Class	
10	5	GP	1.7
	6	O	2.5

The number of floodlights and lamp size are computed from the table above.
LAMPS: 500, 750, 1000 or 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 20 feet above green.
POLE SPACING: Not to exceed twice the mounting height.

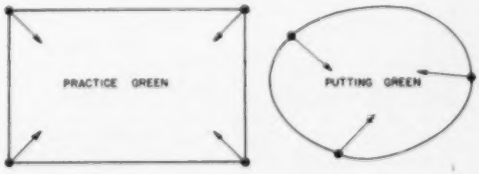
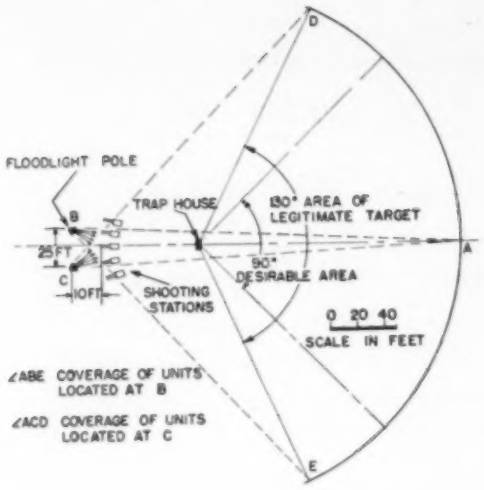


Figure 16. Typical Layout for Practice Putting Greens.



IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		
	Type	Class	No. per Pole
Target (vertical surface at 105 feet) 30 Firing Point (general) 10	2	GP	4

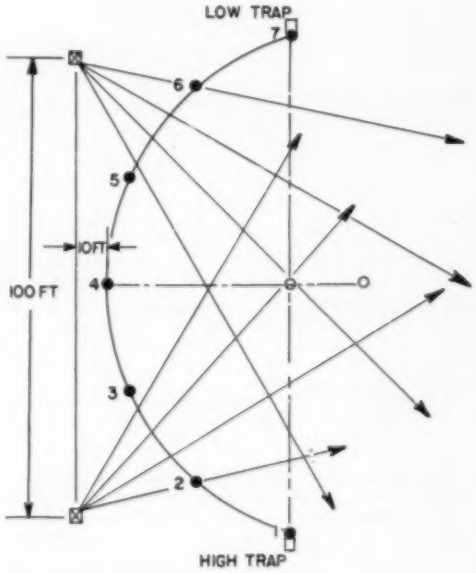
LAMPS: 1500-watt clear general lighting service operated at 10% over rated voltage.
MOUNTING HEIGHT: 20 feet above ground.
POLES: 2.

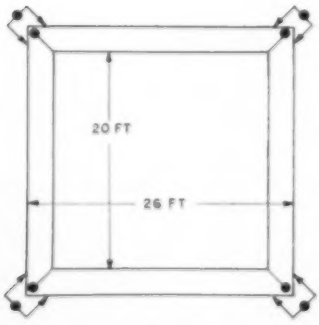
Figure 17. Typical Layout for Trap Shooting.

IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		
	Type	Class	No. per Pole
Target (vertical surface at 60 feet) 30 Firing Point (general) 10	2	GP	4

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 25 feet above ground.
POLES: 2.

Figure 18. Typical Layout for Skeet Shooting.





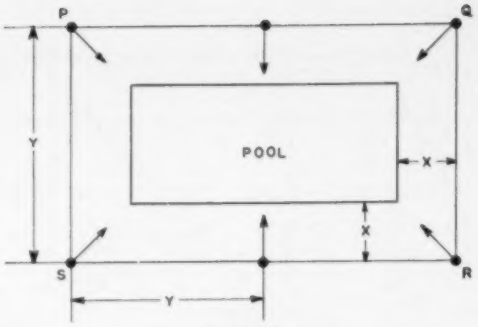
Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
		Type	Class	No. per Pole	Lamp Size (watts)
Championship	500	3 or 4	GP O	4 8	1500 1500
Professional	200	4 or 4	GP O	2 3	1500 1500
Amateur	100	4 or 4	GP O	2 2	1000 1500

LAMPS: Clear general lighting service operated 10% over rated voltage, except Amateur which should be operated at rated voltage.
MOUNTING HEIGHT: 15 to 20 feet above ring.

Figure 19. Typical Layout for Outdoor Boxing and Wrestling Rings.

IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		Watts per Square Foot Area P-Q-R-S*
	Type	Class	
10	5	GP	1.7
	6	O	2.5

*The rectangle P-Q-R-S outlines the area to be lighted.
The number of floodlights and lamp size are computed from table above.
LAMPS: 500, 750, 1000 or 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 20 feet above water.
POLE SPACING: Not to exceed 4 times mounting height.



DIMENSIONS
X—20 FT OR MORE
Y—NOT TO EXCEED 4 TIMES MOUNTING HEIGHT

Figure 20. Typical Layout for Outdoor Swimming Pools (Overhead Lighting).

Location of Pool	Watts per Square Foot of Pool Surface (width × length)	
	Good Practice	Minimum
Outdoors	3.0	1.5
Indoors	5.0	3.0

DIMENSIONS

Lamp Size (watts)	B Max. (feet) (where D is over 5 feet)	B' Max. (feet) (where D is less than 5 feet)	E (inches below water line)	
			Min.	Max.
250 to 400	8	10	12	15
500 to 1500	12	15	18	24

Above lighting uses specially designed floodlights not covered by I.E.S. Classification or Type. Two systems are used—wet niche and dry niche. The former uses submersible units, while in the latter the casings or niche linings are cast in the pool walls with the floodlights behind them.
Use minimum number of floodlights that will satisfy distribution and watts per square foot.
LAMPS: Clear floodlight service operated at rated voltage.

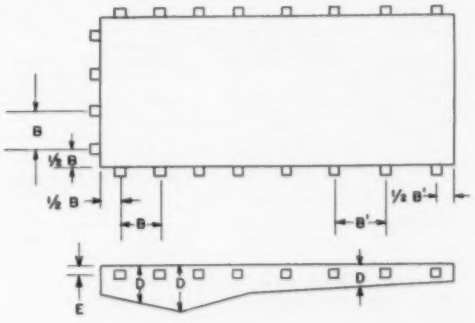
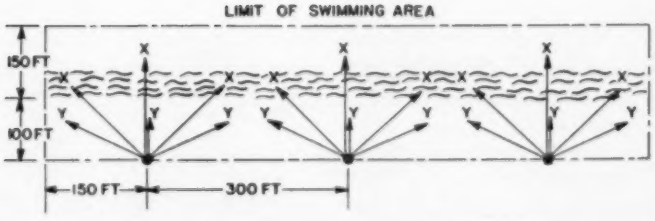


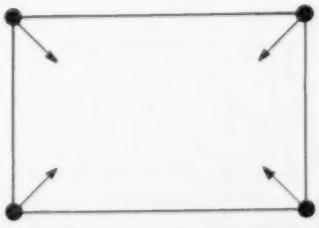
Figure 21. Typical Layout for Outdoor Swimming Pools (Underwater Lighting).



IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
	Aiming Point	Type	Class	No. per Pole
3 (vertical) in surf at 150 feet	X	3	GP	3
1 on beach	Y	5	GP	3

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 60 feet above beach.
POLES: One pole every 300 feet.

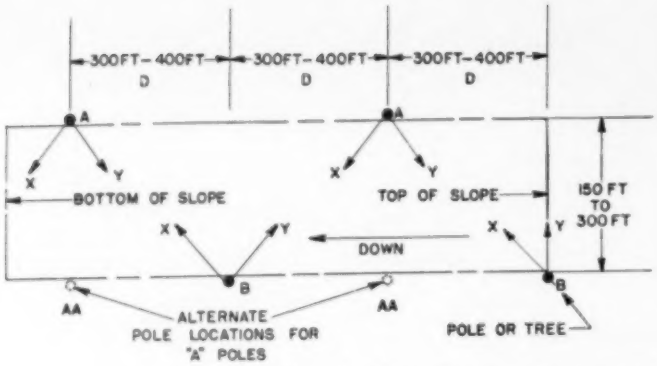
Figure 22. Typical Layout for Bathing Beaches.



IES Current Recommended Practice—Footcandles Maintained in Service	Type	Class	Watts per Square Foot of Area
5	5	GP	.85
	6	O	1.25

The number of floodlights and lamps are computed from the above table.
LAMPS: 500, 750 or 1000-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 20 feet above ground.
POLE SPACING: Not to exceed four times mounting height.

Figure 23. Typical Layout for Playgrounds.



IES Current Recommended Practice — Footcandles maintained in service—0.5.

Floodlights:

Description: Floodlights marked "X"—Type 3, 4 or 5, class GP. Floodlights marked "Y"—Type 3, 4 or 5, class GP.

Number: Provide single floodlights or banks of floodlights according to area to be lighted, based on 0.03 watts per square foot of area.

Distribution: Distribute floodlights to project approximately in ratio of 3 watts in direction of travel (designated by "X" arrows), and 1 watt opposing direction of travel ("Y" arrows).

LAMPS: 500, 750, 1000 or 1500-watt general lighting service operated at rated voltage.

MOUNTING HEIGHT: Not less than 1/10 dimension "D."

NOTES: The above layout is intended for slopes which are free from obstructions. Uphill floodlights are to be set over 500 watts each, and with stippled or elliptical spread cover glass.

Figure 24. Typical Layout for Practice Ski Slopes.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	No. of Courts	Floodlights				
			Type	Class	No. per Pole X	No. per Pole Y	Lamp Size (watts)
Tournament	10	4-6	5 or 6	GP	1	1	1500
				O	2	2	1000
		1-3	5 or 6	GP	1	*	1500
				O	2	*	1000
Recreational	5	4-6	5 or 6	GP	1	1	750
				O	1	1	1000
		1-3	5 or 6	GP	1	*	750
				O	1	*	1000

*For 1-3 courts no "Y" poles are required.
LAMPS: General lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 20 feet above courts.
POLES: Four for 4-6 court layout, two for 1-3 court layout.

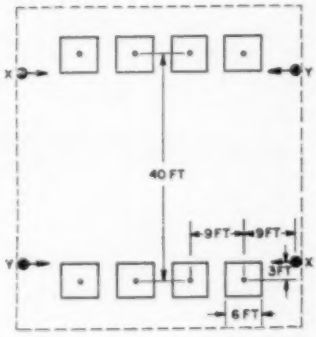
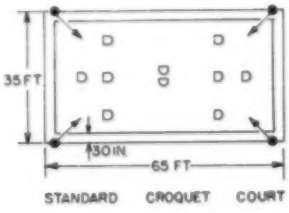
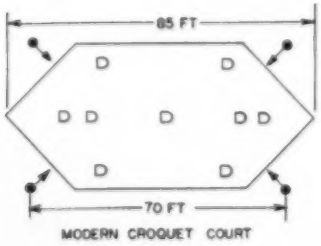


Figure 25. Typical Layout for Horseshoe Courts.





Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
		Type	Class	No. per Pole	Lamp Size (watts)
Tournament	10	5 or 6	GP	1	1000
			O	1	1500
Recreational	5	5 or 6	GP	1	500
			O	1	750

LAMPS: General lighting service operated at rated voltage.
MOUNTING HEIGHT: 20-25 feet above court.

Figure 26. Typical Layout for Croquet Courts.

Class	IES Current Recommended Practice—Footcandles Maintained in Service	No. of Courts	Floodlights				Lamp Size (watts)
			Type	Class	No. per Pole X	No. per Pole Y	
Tournament	10	4-6	5 or 6	GP	1	1	1500
				O	2	2	1000
		1-3	5 or 6	GP	1	*	1500
				O	2	*	1000
Recreational	6	4-6	5 or 6	GP	1	1	750
				O	1	1	1000
		1-3	5 or 6	GP	1	*	750
				O	1	*	1000

*For 1-3 courts no "Y" poles are required.
LAMPS: General lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 20 feet above courts.
POLES: Four for 4-6 court layout, two for 1-3 court layout.

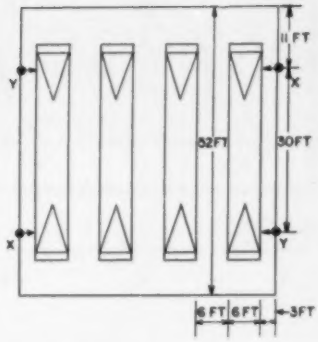
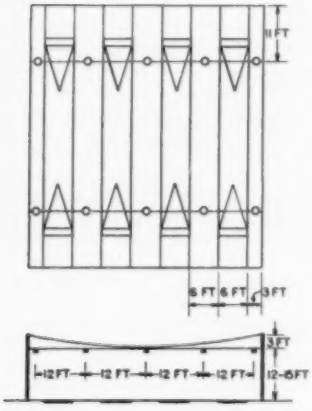


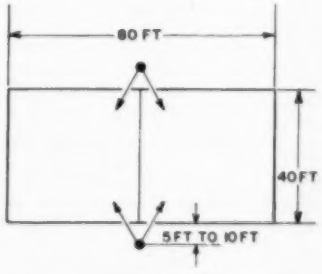
Figure 27. Typical Layout for Outdoor Shuffleboard Courts Using Floodlights.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Luminaire Designation	Quantity per 4 Courts	Lamp Size (watts)
Tournament	10	Direct (spread distribution)	10	500
Recreational	5	Direct (spread distribution)	10	300

LAMPS: 300 or 500-watt inside frost general service.
MOUNTING HEIGHT: As shown.

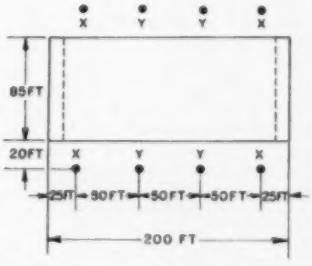
Figure 28. Typical Layout for Outdoor Shuffleboard Courts Using Indoor-type Lighting Units Adapted for Outdoor Use.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		
		Type	Class	No. per Pole
Tournament	20	5 or 6	GP	3
			O	5
Recreational	10	5 or 6	GP	2
			O	3

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 30 feet above court.
POLES: 4.

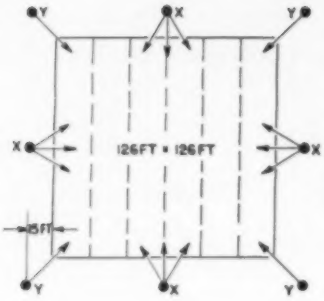
Figure 29. Typical Layout for Outdoor Volleyball Courts.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
		Type	Class	No. per Pole X	No. per Pole Y
Amateur League	20	5 or 6	GP	4	4
			O	7	7
Recreational	10	5 or 6	GP	3	2
			O	5	4

LAMPS: 1500-watt general lighting service. For Amateur League hockey operate at 10% over rated voltage; for Recreational hockey operate at rated voltage.
MOUNTING HEIGHT: 40 feet above ice.
POLES: 6.

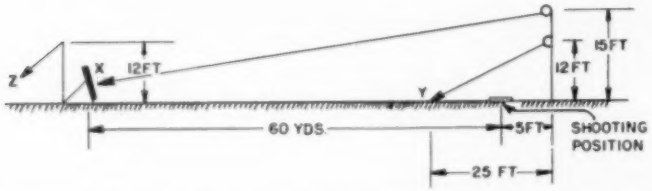
Figure 30. Typical Layout for Outdoor Ice Hockey Rinks.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
		Type	Class	No. per Pole X	No. per Pole Y
Recreational	5	5 or 6	GP	3	1
			O	4	2

LAMPS: 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: 25 feet above ground.
POLES: 8.

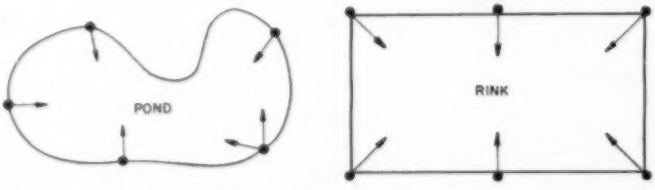
Figure 31. Typical Layout for Bowling Greens.



Class	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights			
		Aiming Point	Type	Class	No. per Pole
Recreational	5	X	1	GP	1
		Y	5	GP	1
		Z	5	GP	1

LAMPS: X 1000-watt floodlighting service (G-40).
Y 500-watt general lighting service operated at rated voltage.
Z 300-watt general lighting service operated at rated voltage.
POLES: One per target located about two feet to left of direct line with target, and one located behind target.

Figure 32. Typical Layout for Outdoor Archery Range.



	IES Current Recommended Practice—Footcandles Maintained in Service	Floodlights		Watts per Square Foot of Area
		Type	Class	
Rinks	5	5	GP	.85
		6	O	1.25
Ponds	1	5	GP	.17
		6	O	.25

The number of floodlights and lamp size are computed from the table above.
LAMPS: 500, 750, 1000 or 1500-watt general lighting service operated at rated voltage.
MOUNTING HEIGHT: At least 20 feet above ice.
POLE SPACING: Not to exceed 4 times mounting height.

Figure 33. Typical Layout for Outdoor Skating Areas.

"Current Recommended Practice for Sports Lighting—Part II," covering lighting for interior sports, will appear in the February 1952 issue of ILLUMINATING ENGINEERING.

T E L E C A S T

LIGHTING NEWS OF CURRENT INTEREST

New Administration Holds Council Meeting in New York

The first meeting of the recently elected new Council of I.E.S. was held October 11, 1951 at the Lexington Hotel, New York City.

As prescribed by the Constitution, the Society's Annual Meeting was also held, preceding the meeting of Council. At this meeting, the General Secretary presented for the record the reports of the President as given at the Washington, D. C. Conference and the report of the General Secretary as it will appear in the December 1951 issue of ILLUMINATING ENGINEERING, as the Proceedings of the Society for the past fiscal year. Action was taken by Council to accept these reports as the record of the Proceedings of the Fiscal Year ending September 30, 1951.

The General Secretary also presented the following Resolution — "That each and every action taken and things done by the Council and the officers of the Society as shown by the Minutes of their meetings since October 12, 1950, and the foregoing reports, be and the same are hereby ratified, approved and confirmed."

The Annual Meeting was closed by an expression of appreciation of the Council and the Society for the contributions made by President Walter Sturrock.

The Council meeting was called to order by President S. G. Hibben presiding, with the following Council members attending:

S. G. Hibben, President; Walter Sturrock, C. H. Goddard, Past Presidents; E. M. Strong, A. H. Manwaring, Vice-Presidents; C. C. Keller, General Secretary; C. F. Hartenstein, Treasurer; G. W. Beals, D. M. Jones, R. L. Biesele, Jr., Roy A. Palmer, J. S. Schuchert, and N. Macdonald (proxy for L. A. Hobbs), Directors; F. P. Labey, P. H. Hildebrand, F. C. Winkler, C. N. Laupp, R. G. Slauer, R. C. Pasley, W. E. Folsom, Regional Vice-Presidents, and A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; C. E. Ellis, Advertising and Promotion Manager; E. C. Huerkamp, Chairman Publications Committee and M. N. Waterman, Chairman Finance Committee.

NEW MEMBERS ELECTED

Following approval of Minutes and other Council business, action was taken on the report of the General Board of Examiners electing to membership 21 Members of the Society. The Board of Examiners also reported the election of 94 Associate Members and 17 Student Members. Membership statistics, including these elections and all other changes are shown in the following tabulation:

September 30, 1951		October 11, 1951
7166	Total Membership	7247
32*	Members Emeritus	32*
42	Fellows	42
1709	Members	1725
5174	Associate Members	5225
209	Student Members	223

*Includes 10 Fellows of the Society.

The Financial Report of the Society, presented by A. H. Manwaring was accepted by Council, as was the budget for the Society's operation for 1951-1952, as presented by M. N. Waterman.

MEMBERSHIP CAMPAIGN

R. G. Slauer, Chairman of the Membership Committee detailed for Council's information the new plan being set up this year for the inter-Section and Chapter membership prize campaign. The basic difference from former campaigns is that each group will compete only with Sections and Chapters of comparable size. To this end, all are divided into four groups based on the present number of members (excluding Students). The groups are as follows:

Group 1—All Sections with 200 or more members.

Group 2—All Sections or Chapters with 100-199 members.

Group 3—All Sections or Chapters with 50-99 members.

Group 4—All Chapters with less than 50 members.

Awards will be made on the *percentage net increase* (excluding Students) as of the record September 1, 1952. Groups 1, 2 and 4 will be awarded two prizes each; Group 3 will be given an extra award because it includes the largest number of Sections and Chapters.

Prizes are:

First Place—in each group—$30.00
Second Place—in each group—$20.00
Third Place—in each group three only—$10.00

There will be no quota as such. A Section or Chapter remains in the same group for the entire 11 months of the campaign, even if its total increase tends to push it higher. There will be no special bonus for converting Associates into Members.

PUBLICATIONS OPERATION

The annual report on the Society's Publications program was presented to Council by E. C. Huerkamp, Chairman. Council studied a chart showing the financial operation as compared to budget, in detail and in terms of cost per member. He outlined for Council's information publication plans for the coming year, including a possible 80-page book to accommodate Conference Papers and plans for a published Proceedings, with discussion.

Mr. Huerkamp reported that the Membership Roster published this year could not be self-liquidating in the present circumstances of cost vs distribution.

HANDBOOK

Mr. Huerkamp also reported on the new edition of the I.E.S. Lighting Handbook now on the press. He said that the book will be out before January 1st. He noted, for Council's information, that the original estimate of 670 text pages had grown to 818, and that an original estimated 25% new material had grown to 75% new and 25% revised. These factors have all affected the time required to publish the book.

LOCAL ACTIVITIES

A. H. Manwaring, Chairman of the Local Activities Committee, welcomed to Council four newly elected Regional V-Ps. He outlined to Council highlights of a committee meeting held recently, indicating that a Guide for Regional Vice-Presidents is ready for mailing and that preparation of a Guide for the Operation

of Regional Conferences is now completed. He noted also that a list of speakers for I.E.S. meetings is available.

NEW CHAPTER

Petition for a Chapter Charter was made by a group of I.E.S. members in Phoenix, Arizona. Communications from the group and supporting material to their petition was more than adequate to qualify for a Chapter, by Constitutional requirements. A Charter for the new Arizona Chapter was granted by unanimous action of Council. Temporary officers appointed are — Chairman, J. D. Whitnell and Secretary, T. L. Buckley, both of Central Arizona Light & Power Co., Phoenix, Arizona.

In a general discussion of local activities, Mr. Manwaring indicated that groups in Tulsa, Peoria, Memphis and Corpus Christi are very active and may petition soon for new I.E.S. Chapters.

He noted also that a new Region, to be the Rocky Mountain Region, may be established in the near future.

All I.E.S. Regions To Hold Conferences

For the first time in I.E.S. history all the nine Regions of the Society will hold full-scale conferences this coming year. Plans are nearing completion for many of them, to be held on dates given on page 8A.

President S. G. Hibben plans to attend all of them—also something of a record.

High Interest in Merit Award Competition Among Owners and Users

Interest, among Owners and Users of outstanding lighting installations, in the $2500 Merit Award Competition sponsored by the Fourth International Lighting Exposition and Conference, is greater than ever, according to reports from G. T. Morrow, Chairman of the Merit Award Committee.

"Entries have been received," says Mr. Morrow, "from a wide variety of Owners and Users, covering installations in office buildings, retail stores, bank offices, automobile showrooms, service stations, schools, churches, industrial plants, airports, municipalities and recreational areas."

The special classification which permits an Owner or User to submit an entry on a lighting installation made between July 1, 1950 and December 31, 1951, was first incorporated in the Third International Lighting Exposition Merit Award Competition. Because of the record number of entries received from this group, it is again included in this competition as one of the major classifications. In addition to Owners and Users, others eligible to submit lighting case studies for Merit Awards or Gold Seal Merit Awards are:

Electrical Contractors
Utility Lighting and Power Representatives
Electrical Distributors' Lighting Specialists and Salesmen
Architects and Consulting Engineers

The new Official Rules simplify methods of presentation of entries for what has become one of the lighting industry's most coveted and distinguished awards. "One does not have to be an engineer to obtain lighting recognition in this Competition," Mr. Morrow points out. "A simple, factual presentation, giving complete lighting data and outlining the increased benefits and advantages of the new lighting installation, is sufficient. Architects, electrical contractors or electrical wholesalers will be only too glad to help in the preparation of the necessary material for your entry. The Official Rules permit joint entries between an Owner and User and an architect, electrical contractor, or any other person or firm eligible under the rules."

Complete details, including information on how to enter, how to prepare entries, how the reports will be judged, etc., are available in the new Official Rules Brochure which includes the application blank. All requests should be directed to the Merit Award Committee, Fourth International Lighting Exposition, 326 West Madison Street, Room 818, Chicago 6, Illinois.

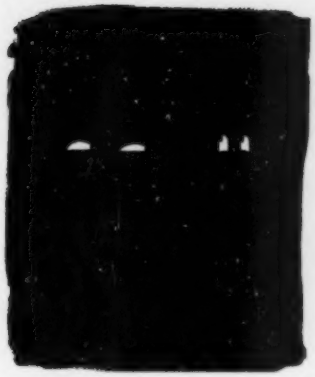
Contractors Compete for Prizes In Fall Lighting Campaign

Electrical contractors of the Philadelphia area attended a meeting held at the Edison Building, Philadelphia, September 13, to launch the Fall Lighting Campaign, an activity conducted annually by the Electrical Association and Philadelphia Electric Company.

A signal was given contractors to "fire away" at prizes offered in a special fund of $750 sponsored by the following five electrical contracting groups: Independent Electrical Contractors Association, Penn-Del-Jersey Chapter of NECA, Delaware County Electrical Contractors Association, Contractors Division of the Electrical Association, and the Bucks-Montgomery Section of the Electrical Association. The fund is planned as awards to contractors for outstanding achievements in industrial, store, office, and exterior lighting.

The campaign will run until January 31, 1952, and contractors are not required to be members of any group to be eligible for one or more prizes. Brochures containing complete information on entering the contest have been mailed to contractors, but anyone failing to receive one may obtain a copy by sending a request to the Electrical Association of Philadelphia.

IT WAS "Old Home Week" for the graduates of Case Institute of Technology at the recent I.E.S. National Technical Conference in Washington, D. C. From left to right, standing, are Professor Russell C. Putnam, Eugene W. Commery, John J. Neidhart, S. G. Hibben, Russell D. Churchill, Gillson W. Beals; seated, Harry E. Schultz, Robert E. Faucett, Lewis B. Moore, Charles E. Strecker, Robert S. Rogge.



"We're awfully proud of this job. We consider it the ultimate achievement in low brightness lighting."

Submitted by Sidney Chilton, member of the Tennessee Valley Chapter, I.E.S., Memphis, Tennessee.

Section Charter to Central New York

A feature of the first meeting of the new Society year, for Central New York (née Chapter) in Syracuse, was presentation of the group's new Section Charter. Presentation was made by Prof. E. M. Strong, Vice-President of I.E.S., to Section Chairman Dr. C. L. Cottrell of Cornell University.

Another feature of the Charter meeting, held October 5 in Corning, N. Y., was a 2½-hour tour of the Corning Glass Center, followed by a dinner meeting at which Frank Neal reported highlights of the National Technical Conference.

S.M.U. to Give Evening Course in Lighting

The Southwestern Section, I.E.S., has made special arrangements with Southern Methodist University to conduct an evening course, E.E. 75, Lighting and Illuminating Engineering, which is open to members of the Society and others directly interested in illuminating engineering problems.

The classes, which meet for three-hour sessions on Tuesdays for sixteen weeks, make up a survey course covering such topics as lighting units and terminology, lighting measurements, sources, fixtures and equipment, interior design methods and calculations applications and wiring design. Instructor for the course is Professor R. L. Biesele, Jr., Research Professor of Engineering at the university.

LIGHTING CALENDAR

Society Events

November 8, 1951—Meeting of I.E.S. Council Executive Committee.

December 13, 1951—Meeting of I.E.S. National Council, New York, N. Y.

January 10, 1952—Meeting of I.E.S. Council Executive Committee.

February 14, 1952—Meeting of I.E.S. National Council, New York, N. Y.

March 13, 1952—Meeting of I.E.S. Council Executive Committee.

March 13-14, 1952—South Pacific Coast Regional Conference, Hotel Sir Francis Drake, San Francisco, Calif.

March 20-21, 1952 — Pacific Northwest Regional Conference, Hotel Victoria, Vancouver, B. C.

March 31, 1952—Meeting of I.E.S. National Council, Chicago, Ill. (Tentative).

April 6-8, 1952—Southwestern Regional Conference, Hotel Tulsa, Tulsa, Okla.

April 20-22 1952—Southern Regional Conference, Hermitage Hotel, Nashville, Tenn.

April 30 - May 2, 1952—Canadian National Conference, Hotel General Brock, Niagara Falls.

May 5-6, 1952—Great Lakes Regional Conference, Statler Hotel, Cleveland, Ohio.

May 8, 1952—Meeting of I.E.S. Council Executive Committee.

May 22-23, 1952—East Central Regional Conference, Webster Hall Hotel, Pittsburgh, Pa.

June 18, 1952—Meeting of I.E.S. Council, New York, N. Y.

June 19-20, 1952 — Northeastern Regional Conference, Hotel Preston, Swampscott, Mass.

July 10, 1952 — Meeting of I.E.S. Council Executive Committee.

September 8-13, 1952 — Illuminating Engineering Society, National Technical Conference, Edgewater Beach Hotel, Chicago, Ill.

Industry Events

November 12-15, 1951 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

November 25-30, 1951 — Annual Meeting, The American Society of Mechanical Engineers, Chalfonte-Haddon Hall, Atlantic City, N. J.

December 2-5, 1951 — American Society of Refrigerating Engineers, 47th Annual Meeting, Hotel Roosevelt, New York, N. Y.

December 5-7, 1951 — Annual Meeting, National Association of Manufacturers, Waldorf-Astoria Hotel, New York, N. Y.

January 6-13, 1952 — The 4th Pan American Congress of Ophthalmology, Del Prado Hotel, Mexico City.

January 12, 1952 — Independent Electrical Contractors Ass'n Inc., Annual Banquet, Hotel Astor, New York City.

January 14-17, 1952 — Plant Maintenance Show, Convention Hall, Philadelphia, Pa.

January 17-24, 1952—National Housewares & Home Appliances Exhibits, Navy Pier, Chicago, Ill.

January 21-23, 1952—National Electric Sign Ass'n, Convention & Exhibit, Hotel Sherman, Chicago, Ill.

January 21-25, 1952—Winter General Meeting, American Institute of Electrical Engineers, Hotel Statler, New York, N. Y.

January 28-30, 1952—The American Society of Heating & Ventilating Engineers, 58th Annual Meeting, St. Louis, Mo.

February 7-8, 1952—Instrument Society of America, New York Section, 1952 Regional Conference on Power Plant Instrumentation, Hotel Statler, New York, N. Y.

March 3-6, 1952—Institute of Radio Engineers, Convention, Waldorf-Astoria Hotel & Grand Central Palace, New York City.

March 5-8, 1952 — Essex Electrical League, Seventh Annual Electrical Industrial Exposition, Terrace Ballroom, Newark, N. J.

March 10-13, 1952 — National Electrical Manufacturers Ass'n, Edgewater Beach Hotel, Chicago, Ill.

March 22 - April 6, 1952—Chicago International Trade Fair, Navy Pier, Chicago, Ill.

March 24-26, 1952—American Society Mechanical Engineers, Spring Meeting, Seattle, Wash.

April 1-3, 1952 — Edison Electric Institute, Sales Conference, Chicago, Ill.

April 1-4, 1952—Greater New York Safety Council, 22nd Annual Safety Convention & Exposition, Hotel Statler, New York City.

April 28 - May 3, 1952 — Chamber of Commerce, Annual Meeting, Washington, D. C.

May 6-9, 1952 — Fourth International Lighting Exposition & Conference, Cleveland Municipal Auditorium, Cleveland, Ohio.

June 2-21, 1952—International Organization for Standardization (ISO) General Assembly, Council and a Number of Technical Committees, Columbia University, New York, N. Y.

Week of June 9, 1952—44th Annual Convention, National Association of Electrical Distributors, Atlantic City, N. J.

June 23-27, 1952 — Summer General Meeting, American Institute of Electrical Engineers, Hotel Nicollet, Minneapolis, Minn.

Week of June 23, 1952—American Society for Testing Materials, 50th Anniversary Meeting, Hotels Statler and New Yorker, New York, N. Y.

August 19-22, 1952 — Pacific General Meeting, American Institute of Electrical Engineers, Phoenix, Ariz.

September 8-10, 1952—American Standards Association's Third National Standardization Conference, Museum of Science and Industry, Chicago, Ill.

October 1-3, 1952—Canadian Electrical Manufacturers Association, 8th Annual Meeting, General Brock Hotel, Niagara Falls, Ontario.

October 13-17, 1952—Fall General Meeting, American Institute of Electrical Engineers, New Orleans, La.

October 20-24, 1952—40th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 10-13, 1952—National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

January 19-23, 1953—Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 9-12, 1953—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

Week of May 24, 1953—45th Annual Convention, National Association of Electrical Distributors, Stevens Hotel, Chicago, Ill.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953—Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-30, 1953—25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

November 9-12, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

C.L.I. Clinic on Light In Photography

For the third successive year, Chicago Lighting Institute presented an entire week of discussions and demonstrations on "How to Use Artificial Light in Amateur Photography." Fifteen speakers, representing light source, film, and equipment companies presented 23 topics.

The clinic was held at the Institute headquarters in Chicago, November 5 through November 9, in fifteen sessions, three sessions daily. Co-sponsors of the free clinic were the Chicago Area Camera Clubs Association and the Associated Amateur Cinema Clubs.

Pittsburgh Section Sponsors Illumination Course

The Pittsburgh Section, I.E.S., in cooperation with the Electric League of Western Pennsylvania is sponsoring a course in Fundamentals of Illumination. The ten weekly meetings, which began October 8, include lectures and demonstrations covering the following topics:

1. Light is What You Make It: Light and Vision, Illumination Terminology.
2. Quantity Requirements of Good Illumination; Quality Requirements of Good Illumination; Importance of Color Illumination.
3. Incandescent, Electric Discharge and Fluorescent Lamps.
4. Principles of Light Control; Systems of Light Control; Calculation of Interior Illumination.
5. Office and School Lighting.
6. Store Lighting, Part I.
7. Store Lighting, Part II.
8. Industrial Lighting, Part I.
9. Industrial Lighting, Part II.
10. Floodlighting.

RETIRING Chairman of the Carolinas Chapter, D. Mack Woodside, hands over the gavel to his successor, Norman E. Tindal. Other new officers of the Chapter include J. W. Lewis, Vice-Chairman and George W. Wilkinson, Secretary-Treasurer.

CMP Office Moves Back to Pentagon

The Central Military Procurement Office has been moved back to the Pentagon. As a convenience to visiting business men, the office had been located in the Old Post Office building in Washington last April, but it was found that the location closer to service information sources was more desirable. New location is Room 3-D-758, Pentagon; phone number remains the same, LIberty 5-6700, extension 66151.

I.E.S. Regional Conferences, 1951-1952

Region	Place	Date
South Pacific Coast	Sir Francis Drake Hotel San Francisco, Calif.	March 13-14
Pacific Northwest	Victoria, B. C.	March 20-21
Southwestern	Hotel Tulsa Tulsa, Okla.	April 6-8
Southern	Hermitage Hotel Nashville, Tenn.	April 20-22
Canadian	General Brock Hotel Niagara Falls, Ont.	April 30 - May 2
Great Lakes	Statler Hotel Cleveland, Ohio	May 5-6
East Central	Webster Hall Hotel Pittsburgh, Pa.	May 22-23
Northeastern	Hotel Preston Swampscott, Mass.	June 19-20

Occupational Vision Congress Held by Georgia Tech

The Georgia Institute of Technology's Fourth Occupational Vision Congress, of which the Georgia Section, I.E.S., was one of seven sponsors, was held in Atlanta on October 4 and 5.

At the sessions, professional eye men—optometrists and ophthalmologists—met with industrial executives to discuss the matching of men to jobs, visually speaking.

Jack H. Murrah, past president of the Section, presided over the afternoon session of the second day, which included a paper by Willard Allphin, Sylvania Electric Products, Inc., on "The Cost of Seeing a Critical Industrial Task." E. A. Linsday, Lamp Division of General Electric Co., also spoke on "Industrial Seeing."

The Congress was presented by the Engineering Extension Division of Georgia Tech. Co-sponsors with the Georgia Section, I.E.S., were:

Associated Industries of Georgia
Cotton Manufacturers Assn. of Georgia
Georgia Association of Industrial Nurses
Division of Industrial Hygiene, Georgia Department of Public Health
Georgia Optometric Assn.
Georgia Society of Ophthalmology and Otolaryngology.

Building Research Congress Held in London

A congress of over a thousand architects, engineers and others interested in building design and construction was held in London, England, from the 11th to 20th of September. Some ninety invited papers were presented by well-known authorities from different parts of the world and these were grouped in three Divisions concerned respectively with (1) the engineering and structural aspects of building, (2) building materials and (3) the various factors which influence the comfort and efficiency of the occupants of buildings. The work of Division (3) was again sub-divided under the headings of (1) acoustics, (II) heating and ventilation, (III) lighting and (IV) special problems in factories, hospitals and schools.

There were four sessions on lighting. At the first, Dr. Ward Harrison and Phelps Meaker communicated a paper on brightness engineering in which they explained the principles underlying the use of glare factors and the "three to one" rule of the Q. and Q. Committee. Research on methods of appraisal of comfort conditions in lighted interiors has been in progress at the British Building Research Station and this was described

(Continued on page 10A)

MITCHELL **module**
REG. U. S. PAT. OFFICE

America's *NO. 1* Commercial Lighting

From coast to coast, MITCHELL MODULE is rated America's No. 1 Commercial Lighting because it more efficiently, more economically, more completely fills the widest range of commercial lighting needs.

Planning is simple because MODULE forms over 50,000 practical custom-type patterns—provides proper lighting for *all* interior areas in establishments of *any* size.

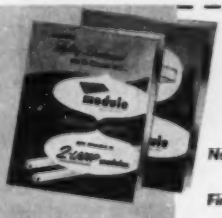
Installation is quick and economical because MODULE units interconnect mechanically and electrically—mount in rigid alignment with minimum time and work.

Lighting Efficiency is extraordinary (up to 20% greater light output reported from hundreds of installations). All these advantages, plus enduring beauty and low cost, explain why MODULE is definitely preferred by contractors, wholesalers, utility consultants, architects and users everywhere.

See how easy it is to solve your commercial lighting problems—be sure to get full details on MITCHELL MODULE today.

the full MODULE opportunity

Learn all about MODULE—see how specification and use of proper lighting is simplified by this exclusive custom-fitting system. MITCHELL MODULE Catalogs No. 360 and 370 give you the full story. Write for your free copies today.



MITCHELL MANUFACTURING COMPANY
2525 N. Clybourn Ave., Chicago 14, Illinois
In Canada: Mitchell Mfg. Co., Ltd., 19 Waterman Ave., Toronto

Mitchell Manufacturing Company
2525 N. Clybourn Ave., Chicago 14, Illinois

☐ Send MODULE Catalogs No. 360 and 370

Name_____

Firm_____

Address_____

City_____ Zone___ State_____

(Continued from page 8A)

by Dr. R. G. Hopkinson who mentioned the advantages which had been found to result from grading the contrast between a bright light source and its background. The third paper given at this session was by H. C. Weston who described the research and the arguments behind the code of recommended values of illumination published by the British Illuminating Engineering Society.

At the second lighting session the first paper was contributed by Prof. R. L. Biesele, Jr., who described the experiments on school lighting carried out in Texas schools over a number of years. On the subject of artificial lighting he referred his audience to the American Standard Practice for School Lighting, from which he gave a number of extracts. With regard to daylight he described the systematic studies now in progress under his direction at the Southern Methodist University of Texas in the special school-lighting test house erected there.

A paper on "Factory Lighting in Great Britain" was given by W. Allen and J. B. Collins and this was followed by a very interesting account of the work being done in Australia on the daylighting of factory buildings. The authors were Dr. A. Dresler and A. L. Brentwood, both of the Australian Department of Labour and National Service. They said that it was not uncommon for factories to be able to dispense with the use of artificial lighting altogether, for a number of reasons, among them the normal span of working hours and the availability of space for single story buildings. In a Bulletin published in 1948 a daylight factor of 1·2 per cent was recommended for rough work, 2·4 per cent for medium work and 4·8 per cent for fine work. Various aids to designs of buildings had been devised, including some concerned with the control of sunlight penetration. Still further assistance was provided by the issue of "screening assessment sheets" which gave, for a particular locality, the time of sunlight penetration through unscreened windows, the times of maximum direct glare and other data to assist in the selection of the most suitable sunbreaks to provide adequate screening.

NEWLY elected Chairman of the Southern California Chapter, S. H. Simonsen, is installed in office by William P. Bear, Member Emeritus of the Society. After the official ceremonies of retirement and installation of officers, the program continued with a highly successful Amateur Talent Show, the members participating.

At the third lighting session there were four papers on daylight. One, by L. H. McDermott and G. W. Gordon-Smith, gave the results of photoelectric records of skylight illumination for all times of the day and year, taken over a period of five years at the National Physical Laboratory, England. The second, by P. Petherbridge, discussed the use of daylight factors and sky factors for assessing the lighting conditions in a building while in the fourth W. Allen and J. B. Bickerdike discussed the influence of daylight research on building design. The third paper by Gunnar Pleijel of the Royal University of Technology at Stockholm described research carried out in Sweden on the daylight conditions in blocks of flats built around a central courtyard. Most of this work was done with models and Mr. Pleijel described an artificial sky, some 20 feet in diameter and uniformly illuminated to about 50 footcandles, which was available in his laboratory for such work.

At the fourth and final lighting session two papers were presented on the use of color schemes in buildings. The first paper was by Faber Birren, who described much of the work done in this subject in American factories and elsewhere, while the other by H. L. Gloag treated the subject from the British point of view. After a brief discussion, Dr. J. W. T. Walsh gave a general review of the principal points brought out during the presentation of the papers and the subsequent discussions.

In addition to the technical sessions and the general meetings held on the first and last days of the Congress there were a number of social events including a reception given by the British Government, and a long list of visits to places of technical interest from which delegates could select those which appealed most to them. The papers and discussions are published in four volumes by the Bureau of the Congress, 57 Onslow Gardens, London, S.W.7, England.

Photo courtesy Thomas W. Haslam, Georgia Power Co.

OFFICERS of the Georgia Section, I.E.S. for 1951-1952 who were installed at its first Fall meeting in September are, left to right, T. A. Willis, board of managers; Robert J. Kusell, secretary-treasurer; H. M. Horton, past chairman and member of the board of managers; T. Taylor Peake, chairman; J. Dixon Mitchell, vice-chairman; and H. R. Chappell, board of managers. Highlights of the meeting included a report on the National Technical Conference by several members who attended, and an illustrated address on Panelescent light by R. G. Slauer, Sylvania Electric Products, Inc., Salem, Mass.

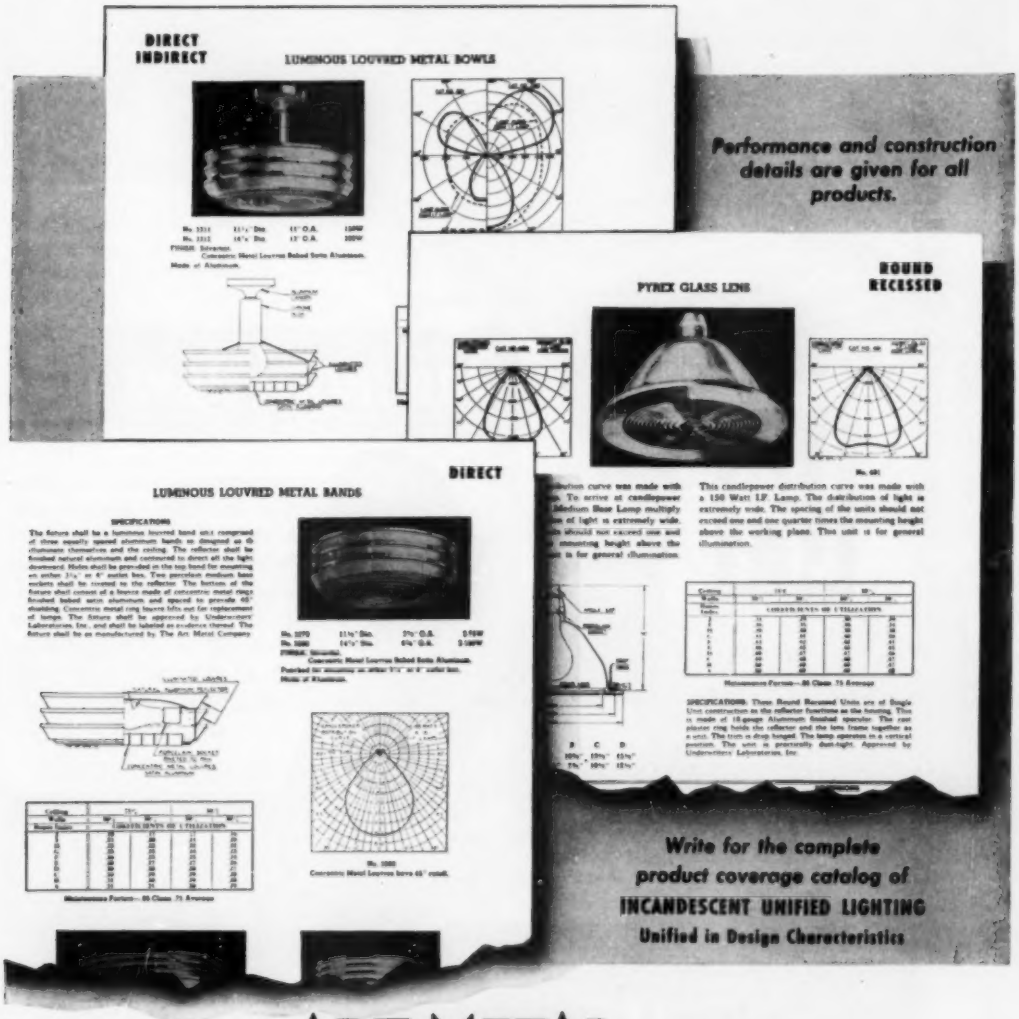
Lighting-At-Work Show Touring Country

A mobile show designed to present useful lighting information to architects, consulting engineers and lighting service people, is presently touring the country under the sponsorship of the Westinghouse Electric Corp.

Presented in skit form, the show demonstrates with slides, charts and a simulated architects' office, lighting applica-

(Continued on page 15A)

ART METAL gives explicit data to speed specification writing and installation planning for all types of INCANDESCENT LIGHTING



THE ART METAL COMPANY

CLEVELAND 3, OHIO

Manufacturers of Engineered Incandescent Lighting

NEW HIGH IN

LPI

Luv-K-Lok

(PATENTS PENDING)

AN EDWIN D. TILLSON DESIGN

One hand does it!

LPI

Removable louvers slip in and out like safety razor blades. A quick wiping action cleans both sides of blade simultaneously. Fixture shown here can be cleaned in 3 minutes — about one-tenth the usual time. An *exclusive* LPI patented invention.

Write for FREE LPI HANDBOOK

Lighting Products, Inc., Highland Park, Ill.

LIGHT OUTPUT

As you know, there is a big reduction—often as much as 50%—in foot-candles *unless* louvers and shielding surfaces are cleaned at regular intervals. Trouble is, frequent cleaning of old-style louvers costs a fortune. Now, at last, Luv-R-Lok, an *exclusive* LPI invention, solves the problem with *removable* louvers that slip in and out with finger-tip ease. For a new high in light output—a new level of efficiency at a sensationally low maintenance cost—you can recommend Luv-R-Lok to your clients with the assurance that they will be delighted. Mail coupon today for the LPI Handbook for detailed information and specifications.

Lighting Products, Inc., Highland Park, Ill.

EASY to hang, a feature that easily saves you 50% on labor costs.

EASY to align: a special collar stem adjuster permits accurate alignment *in half the usual time.*

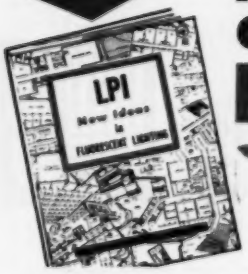
EASY to handle: Luv - R - Lok, without loss of strength, is as much as 25% lighter in weight than old-style fixtures.

EASY to install in continuous rows: ingenious time - saving joiner bridge saves you time and labor.

EASY to replace lamps. Simply lift off removable plastic sides—and the job is done in a jiffy!

FREE HANDBOOK

The LPI HANDBOOK, crammed with New Ideas in Fluorescent Lighting, will give you valuable help in planning lighting layouts for high efficiency at low cost. The Handbook is free. Mail coupon NOW.



MAIL COUPON NOW

Lighting Products, Inc., Highland Park, Ill.

Okay, send me your Free LPI Handbook. I am interested and want to know more, but this request obligates me in no way whatever.

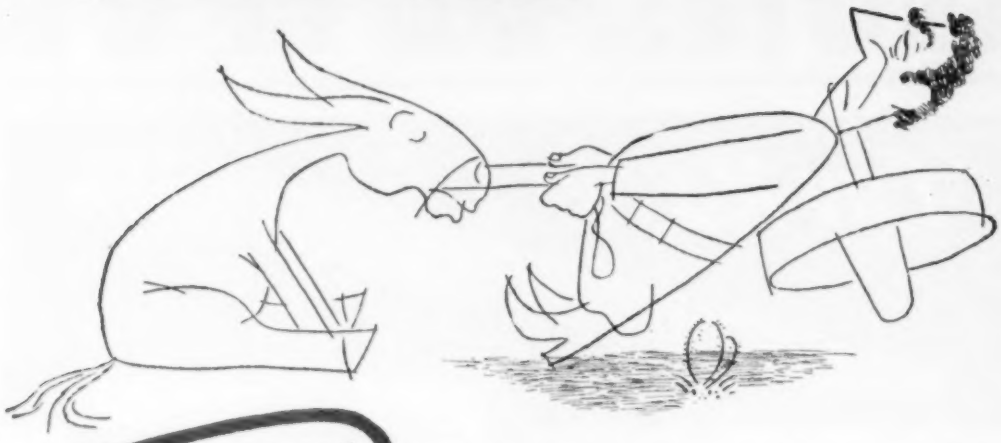
FIRM NAME_____

My Name_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

WHEN THE PROBLEM IS STARTING



THE ANSWER IS BRYANT

Every Bryant Fluorescent Starter is manufactured under the strictest supervision to assure dependable performance and long life. Each starter is:

- **Made from the highest quality materials**
- **Precision assembled to exact specifications**
- **Individually inspected and electrically tested on actual lamp load**

"NO BLINK" TYPES

These starters eliminate blinking and flickering of lamps which have reached the end of their useful life, thereby protecting the ballast and prolonging the life of the starter.

Listed as Standard by Underwriters' Laboratories, Inc.

AUTOMATIC RESET

(Restores the circuit as soon as new lamp is inserted.)

Two pin—for 40, 85, 90 and 100 watt lamps.

Four pin—for 85, 90 and 100 watt lamps.

MANUAL RESET

(Circuit restored by pushing small red button in top of starter, after new lamp has been installed.)

Two pin—for 15, 20, 30 and 40 watt lamps.

Four pin—for 85, 90 and 100 watt lamps.

THE BRYANT ELECTRIC COMPANY

Bridgeport 2, Connecticut

CHICAGO • LOS ANGELES

BRYANT
SUPERIOR WIRING DEVICES

J-00030

(Continued from page 10A)

tion problems covering industrial and commercial areas. The two architects in the skit are played by W. H. Kahler and Sam Davies (in real life well-known lighting engineers). Before a projected set showing an architects' office, the "architects" make case studies of school, office, low-bay, high-bay and other commercial and industrial lighting applications. Possible lighting layouts, types of light distribution patterns, luminaires, lamps, ballasts, and wall, ceiling and floor coverings are discussed for each job, and reasons are given for a particular selection. In many cases, "before" as well as "after" slides are used to show the improvement obtained in both quantity and quality of light. Charts are used to compare the relative costs of incandescent and mercury-arc lighting of low and high bay areas. The advantages and disadvantages of lead-lag and series ballasts are covered frankly.

Comic relief is provided when architects Kahler and Davies use a futuristic "telememory" machine to bring into focus pictures of lighting jobs they have handled. With these giant pictures before them, they trace out the particular application problems encountered and go over the resulting installation.

To make sure of the authenticity and value of the show, the script was submitted to the American Institute of Architects which observed "that it is of value and interest to the architectural profession."

I.E.S. Industrial Film Included in E.C.A. Program

Arrangements are at present under way to make copies of the I.E.S. film "Let us See" available to the Economic Cooperation Administration to be presented through their Technical Assistance Programs in the Marshall Plan countries. "Let Us See" is a motion picture produced by the Illuminating Engineering Society, on industrial lighting.

The film was received enthusiastically by the people who are now using it in Paris, and E.C.A. is eager to re-dub the film in selected foreign languages, using the finished product in their training program.

PROJECTED stage set of architects' office is background for new mobile show now touring the country to demonstrate lighting design to architects. Shown activating the "Telememory" machine are **W. H. Kahler** (left) and **Sam Davies** who form the show's cast.

Lighting Bibliography Available From Headquarters Office

A list of books, publications and periodicals, compiled by the I.E.S. Committee on Lighting Education, for handy use by those in the illumination field, is available from the Technical Department of the I.E.S. headquarters office. Consisting of nine mimeographed sheets, this bibliography on light and lighting covers publications which make a definite contribution to the field of illumination, grouped according to the subject matter which they represent. These phases are (1) Lamps and Lighting, (2) Architecture and Lighting, (3) Physics of Light —Optics, (4) Color, (5) Light, Eyesight and Health — Related Psycho-Physiological References, (6) Trade Papers and Professional Journals in both English and foreign languages.

Luckiesh Book Wanted

Wanted, one copy of "Visual Illusions" by Dr. M. Luckiesh, published by Van Nostrand in 1922. If anyone has a copy he would be willing to sell, please contact Professor C. C. Whipple, 85 Livingston Street, Brooklyn 2, N. Y.

I.E.S. National Technical Conferences

Dates and locations of the next two National Technical Conferences of the Illuminating Engineering Society are:

September 8-13, 1952 — Edgewater Beach Hotel, Chicago, Illinois

Week of September 14, 1953 — Hotel Commodore, New York, N. Y.

ABOUT PEOPLE

D. B. Clayton of Birmingham, Alabama, has been elected president of the National Electrical Contractors Association at the final meeting of its Golden Anniversary Convention in Washington. He succeeds **Erne C. Carlson**, who did not run for re-election.

Plans for the Centennial of Engineering to be held in Chicago next September have taken another step forward with the appointment of **Frank W. Edwards**, director of the department of civil engineering at Illinois Institute of Technology and nationally known hydraulic engineer, as general manager. Selection of Mr. Edwards, who has been granted a leave of absence to direct the $1,000,000 celebration, was announced by its president, Lenox R. Lohr.

In recognition of a lifetime of service and leadership in the cause of standardization, the first award of an annual gold Standards Medal has been made to **Dr. Paul G. Agnew**, consultant to the American Standards Association. Formal presentation of the medal was made at the Second National Standardization Conference in New York, October 22-24.

R. L. Biesele, Jr., who has been chairman of the Department of Electrical Engineering at Southern Methodist University, has been named research

professor of engineering to allow him to continue, full time, his research activities in the field of daylight and illumination.

The president and council of the Engineering Institute of Canada announce the appointment of **Colonel H. G. Thompson** to the post of assistant general secretary.

Sylvania Electric Products, Inc. has appointed **Raymond P. Connors** to the newly created post of eastern sales manager of the Lighting Division. Mr. Connors is a past Chairman of the Western New York Section of I.E.S.

Frank G. Reed has been appointed to be in charge of sales and engineering development for John C. Virden, Ltd., Toronto. Formerly, Mr. Reed was in the Lighting Service Department of The Hydro-Electric Power Commission of Ontario.

(*Continued on page* 19A)

Questions and Answers on Light Sources

The I.E.S. Committee on Light Sources, under the chairmanship of E. H. Raddin, has prepared this listing of answers to frequently-asked questions. Similar questions of general interest on light sources will be published from time to time in this department

Q. Will the ballast have any effect on the light output of a fluorescent lamp?

A. Yes. The light output of a fluorescent lamp is nearly proportional to the lamp watts which are controlled by the ballast. The ballast should provide the rated watts required by the lamp; however, variations do occur as recognized by the tolerances of accepted ballast specifications.

Q. What is the pressure of the gas in a gas-filled tungsten lamp?

A. Under normal operating conditions, the pressure of the gas in the bulb will be about atmospheric pressure. Lamps operated above normal temperature will have greater than atmospheric pressure which may cause the bulb to bulge or blister.

Q. Can different type fluorescent lamps be used in the same fixture providing they fit in the fixture?

A. For proper operation and full lamp value, it is very important that the same size and type lamp be installed for which the fixture was originally designed. Each fixture contains a ballast, and there is a particular type and size of lamp designed for operation with this ballast. In many cases with the new single pin lamps, the 1½-inch diameter tubes and the 1-inch diameter tubes are the same length and both can be physically inserted in the same fixture. The ballast voltage available for starting the 1½-inch diameter tubes is lower than that required for the 1-inch diameter tubes. The larger diameter lamp is designed for a larger operating current than the smaller lamp, and if lamps and ballasts are not matched, improper operating current will result. The 40-watt preheat and 40-watt bi-pin instant-start lamps can be inserted in the same fixture. The instant-start lamp will not operate in a preheat fixture because the lamp contains a short circuiting strip between the pins on each base. This strip is located inside the base. When a preheat lamp is used in an instant-start fixture, the line current which normally flows through the shorting strip then flows through the cathode, resulting in a very short life and excessive end blackening. Both the salesman and the purchaser of lamps should be alert to this condition.

Q. What is the cause of the normal failure of an incandescent lamp?

A. Incandescent lamps normally fail because the filament fails (burns out) after hours of use. This is caused by the evaporation of the filament operating at a high temperature. The loss of tungsten causes the filament to become thinner. The thinning is not uniform throughout the filament but is concentrated in one or more spots, one of which eventually melts open. Actually the loss of filament weight from the time the lamp is first lighted until burnout is only between five and ten per cent. Failures such as bulb breakage, filaments broken by rough handling, excessive vibration, mechanical shocks or over voltage are considered abnormal failures.

Q. What is the cause of the normal failure of a hot cathode fluorescent lamp?

A. A normal failure of a hot cathode fluorescent lamp takes place when there is no more emission coating left on the cathode at one or both ends of the cathode. The cathode, located at each end of a hot cathode fluorescent lamp, is coated with a substance which emits electrons freely, permitting lamp starting and operation. This coating of electron emission material is gradually used up during the life of the lamp and a little is sputtered off when the lamp is started. When no more coating remains on the cathodes, there are not enough electrons to establish or maintain the arc and the lamp has failed from normal causes. Abnormal failures, such as bulb and filament breakage, are similar to incandescent lamps. In addition, what may appear to be lamp failures may be the failure of auxiliary equipment, such as ballasts and starters.

Everyone concerned with specifying or providing ideal luminous-acoustical environments . . . should read this book
Wakefield
CEILING

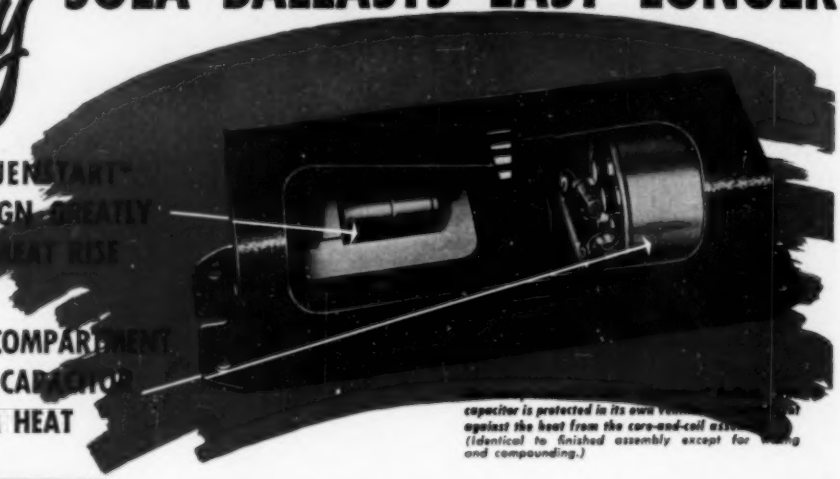
There never was a book like this because there never was a product like this. The Wakefield Ceiling is a completely integrated means of providing total luminous-acoustical environments, produced in accordance with your specifications at the Wakefield factory, shipped complete to the job and installed in its entirety by a Wakefield-licensed electrical contractor. To know about the Wakefield Ceiling you must read this book. A letter on your business stationery will bring you a copy, free of charge. Write to *The F. W. Wakefield Brass Company, Vermilion, Ohio.*

Wakefield Over-ALL Lighting

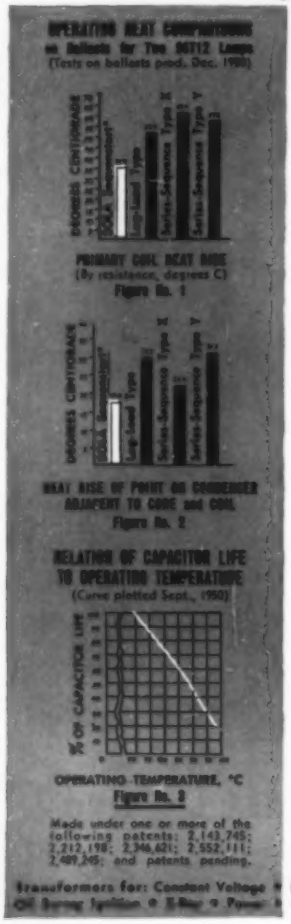
Why SOLA BALLASTS LAST LONGER

SOLA SEQUENSTART* CIRCUIT DESIGN GREATLY REDUCES HEAT RISE

VENTILATED COMPARTMENT PROTECTS CAPACITOR FROM HEAT



capacitor is protected in its own ventilated compartment against the heat from the core-and-coil assembly. (Identical to finished assembly except for wiring and compounding.)



Made under one or more of the following patents: 2,163,749; 2,212,198; 2,346,621; 2,552,111; 2,409,345; and patents pending.

Cool operation is vital to long ballast life. Excessive heat deteriorates impregnating varnish, enamel wire insulation, compound, and other ballast material. Most important, however, excessive heat invariably causes premature capacitor failure.

42.5%-32.2% COOLER CORE and COIL OPERATION

Primary coil temperature rise on SOLA Sequenstart* Ballasts is 42.5% - 32.2% lower, as illustrated by Figure 1. The patented SOLA Sequenstart* circuit greatly reduces the quantity of metal required, minimizing copper and iron losses. This reduces the high heat rise inherent in other designs and, consequently, lowers the high ambient temperature which surrounds ordinary ballasts.

VENTILATED CAPACITOR 13.2°C.-4.4°C. COOLER

Capacitor life is inversely proportional to operating temperatures (see Figure No. 3) . . . ballast life depends on capacitor life. SOLA design and manufacture minimizes capacitor failure in three ways:

- *Finest capacitors manufactured are inspected against rigid standards . . . 100% inspection after a baking cycle.*
- *The significantly lower heat rise of SOLA Sequenstart* Ballasts reduces radiated and conducted heat to the capacitor.*
- *The exclusive ventilated capacitor compartment isolates the capacitor from coil heat by two walls and a buffer of air. The insulating properties of the patented compartment are readily apparent from Figure No. 2. The lower capacitor temperature of the SOLA Ballast can result in as much as 35% longer capacitor life (see Figure No. 3).*

The important property of longer ballast life is but one of many advantages you'll receive when you specify and install SOLA Sequenstart* Ballasts.

New technical information about SOLA Ballasts is in preparation. If you are not on our mailing list, write to us. Ask for future releases on SOLA Fluorescent Ballasts.

SOLA Sequenstart* BALLASTS

*Trademark

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs • Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50, Illinois

(Continued from page 16A)

The establishment of separate divisions responsible for its manufacturing activities has been announced by the Mitchell Manufacturing Company. The Commercial and Industrial Fluorescent Lighting Division will be headed by **Charles Schroeder**; Portable Lamps Division by **Herbert Kahn**. The other divisions are Air Conditioning and Radio and Television.

The addition of **Robert Thallon** to head the department of designs engineering of Fluorescent Fixtures of California, San Francisco, has been announced by Chas. E. Buchanan, vice-president.

Francis K. McCune has been named assistant manager of General Electric's Engineering Service Division. Mr. McCune was formerly manager of engineering of the Large Apparatus Division. Arthur F. Vinson has been appointed assistant manager of the Manufacturing Services Division. Both men will have headquarters in Schenectady.

The appointment of **Don M. Brown** as manager of sales administration for the Westinghouse Lamp Division has been announced. Mr. Brown will be located in Bloomfield, N. J.

Carl H. Rinne has been named general manager of General Electric Company's Transformer and Ballast Department at Fort Wayne, Indiana. He succeeds William C. Wichman, now manager of the Component Products Division.

Two new appointments have been announced by the Westinghouse Corp., Lamp Division. **Harry A. Holden** has been appointed manager of the new Paris, Texas plant that will start production in 1952. His headquarters will be in Bloomfield until then. **Harry F. Fox** succeeds Mr. Holden as manager of the Belleville, N. J. plant.

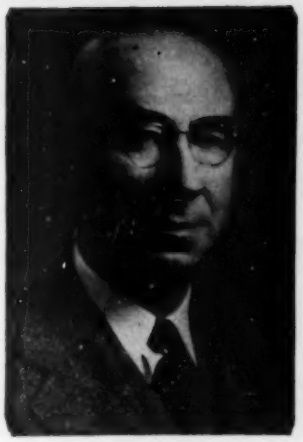
Announcement has been made of the appointment of **Walter J. Seeley** of Duke University as Chairman of the Student Development Committee of the Engineers' Council for Professional Development.

OBITUARIES

George G. Cousins, Fellow and Member Emeritus of the Illuminating Engineering Society died at his home in Port Credit, Ontario, September 20. Mr. Cousins joined the Society in 1914 and was instrumental in the formation of the Toronto Section (then Chapter) in 1921, serving as its Charter Chairman. In 1947-1948, he was Regional Vice-President for the Candian Region and was later Treasurer of the Society.

In recognition of his many services and efforts in the field of illumination, and his leadership in furthering the lighting art, he was elected to the grade of Fellow in 1945.

Mr. Cousins had served for 39 years with the Ontario Hydro Commission as illuminating engineer, where he pioneered



George G. Cousins

in the testing of lamps and lighting fixtures. He also acted as consultant and testing officer for the Ontario Department of Highways, advising on street and highway lighting, safety glass and on all lighting problems affecting highway operations.

On his retirement from active service in 1950, Mr. Cousins was elected to the rank of Member Emeritus.

The Society also regrets the recent deaths of **David Lloyd Markle**, professor emeritus of electrical engineering, Pennsylvania State College and **James A. Toohey**, Division Manager of Sales, Holophane Company, Chicago.

NEW MEMBERS

At the meeting of the Council Executive Committee held in New York City on October 11, 1951, the following were elected to membership:

ALAMO CHAPTER

Member:

Harben, E. B., Electrical & Refrigeration Branch, Engineer Section, 4th Army, Ft. Sam Houston, Texas

BALTIMORE CHAPTER

Associate Member:

Douty, P. F., Douty & Downie, Baltimore, Md.

CAROLINAS CHAPTER

Associate Members:

Butler, P. C., Carolina Power & Light Co., Southern Pines, N. C.
Jordan, C. C., Carolina Power & Light Co., Raleigh, N. C.
McGowan, W. B., Carolina Power & Light Co., Florence, S. C.
Meredith, O. W., Shealy Electrical Wholesalers, Inc., Greenville, S. C.

CENTRAL NEW YORK SECTION

Associate Member:

Surtees, J. W., 96 South St., Auburn, N. Y.

CHICAGO SECTION

Members:

Conrad, R. M., Jr., Beling Engineering Consultants, Peoria, Ill.
Foster, L. N., Foster Electric Co., Peoria, Ill.
Haeger, A. F., Westinghouse Electric Corp., Peoria, Ill.
Lawson, J. C., Lawson Electric Co., Galesburg, Ill.

Associate Members:

Berry, E. A., Caterpillar Tractor Co., Peoria, Ill.
Bourscheidt, Norbert, Jr., Bourscheidt Electric Co., Peoria, Ill.
Carter, C. E., Associated Engineers, Peoria, Ill.
Epstein, H., Advance Transformer Co., Chicago, Ill.
Gallet, E. H., Curtis Lighting, Inc., Chicago, Ill.
Harrison, Hertzel, Steele Harrison Mfg. Co., Peoria, Ill.
Prewett, R. C., Prewett Electric Co., Peoria, Ill.
Remmel, R. J., Moe Light, Inc., Peoria, Ill.

Student Members:

DeVore, J. C., 5847 Blackstone Ave., Chicago, Ill.
Leavitt, A. E., University of Illinois, Urbana, Ill.
McClusky, Val G., University of Illinois, Urbana, Ill.
Underwood, J. D., 1002 College Covet, Urbana, Ill.

CLEVELAND SECTION

Associate Members:

Fulcher, C. A., Westinghouse Electric Corp., Cleveland, Ohio
Odle, H. A., Holophane Co., Inc., Newark, Ohio

Student Member:

Hart, A. L., University of Illinois, Urbana, Ill.

CONNECTICUT SECTION

Associate Member:

Steinhardt, H. L., George J. Steinhardt, Inc., Bridgeport, Conn.

EASTERN PENNSYLVANIA CHAPTER

Members:

Heim, W. H., Pennsylvania Power & Light Co., Sunbury, Pa.
Kelsey, E. W., Pennsylvania Power & Light Co., Harrisburg, Pa.

(Continued on page 33A)

SUSTAINING MEMBERS

Acme Electric Corp.
Cuba, N. Y. *J. A. Comstock*

Advance Transformer Co.
1122 W. Catalpa Ave., Chicago 40, Ill. *Hirsch Epstein*

Alabama Power Co.
Birmingham, Ala. *George L. Morris*

All Bright Electric Products Co.
3917-25 N. Kedzie Ave.,Chicago 18, Ill. *Max Klein*

Aluminum Company of America
Gulf Building, Pittsburgh 19, Pa. *C. Braglio*

Amalgamated Electric Corp., Ltd.
584 Pape Ave., Toronto, Ont., Canada *W. A. Dalrymple*

American Concrete Corp.
4727 North Lamon Ave., Chicago 30, Ill. *J. W. Lewis*

American Fluorescent Corp.
5407 Broadway, Chicago, Ill. *William Rusnak*

American Steel and Iron Works
5801 South Lowe Ave., Chicago 21, Ill. *Walter H. Krueger*

American Sterilizer Co.
Erie, Pa. *Horace Wm. Alexander*

Appleton Electric Co.
1701-1729 Wellington Ave., Chicago 13, Ill. *Nils A. Tornblom*

Arkansas Power & Light Co.
Simmons National Bldg., Pine Bluff, Ark. *Max Sudduth*

The Art Metal Co.
1814 E. 40th St., Cleveland 3, Ohio *George E. Glatthar*

Bausch & Lomb Optical Co.
Rochester 2, N. Y. *Arthur E. Neumer*

Benjamin Electric Mfg. Co.
Des Plaines, Ill. *Benjamin S. Benson*

Blue Ridge Glass Corp.
P.O. Box 651, Kingsport, Tenn. *James Herbert*

Board of Water and Electric Light Commissioners
116 W. Ottawa St., P.O. Box 570, Lansing 3, Mich. *John D. Malnight*

Boston Edison Co.
39 Boylston St., Boston 12, Mass. *R. B. Brown, Jr.*

Branham, Marock & Duepner, Inc.
7020 Walker St., St. Louis Park, Minneapolis 16, Minn. *Cecil H. Branham*

Bright Light Reflector Co., Inc.
Fairfield & State, Bridgeport 5, Conn. *R. J. Mott*

British Columbia Electric Rwy. Co., Ltd.
570 Dunsmuir St., Vancouver, B. C., Canada *H. N. Walters*

Brockton Edison Co.
36 Main St., Brockton 67, Mass. *W. A. Forbush*

Edward F. Caldwell & Co., Inc.
101 Park Ave., New York 17, N. Y. *E. T. Caldwell*

California Electric Power Co.
P.O. Box 512, Riverside, Calif. *Robert W. Dowd*

Calpa Products Co.
4116 Chester Ave., Philadelphia 4, Pa. *Paul C. Calisti*

Cambridge Electric Light Co.
46 Blackstone St., Cambridge 39, Mass. *Reginald H. Bowman*

Canadian General Elec. Co., Ltd.
212 King St., Toronto, Ont. *R. M. Love*

Canadian Laco Lamps, Ltd.
745 Guy St., Montreal, Que. *J. Thomas*

Canadian Line Materials, Ltd.
Postal Station H, Toronto 13, Ont., Canada *L. E. Messinger*

Central Hudson Gas and Elec. Corp.
50 Market St., Poughkeepsie, N. Y. *H. E. Dexter*

Central Illinois Light Co.
516 Jefferson Ave. S., Peoria 2, Ill. *R. K. Dallas*

Central Illinois Public Service Co.
607 E. Adams St., Springfield, Ill. *B. L. Palm*

Central Maine Power Co.
9 Green St., Augusta, Maine *Roland W. Hess*

Central Power & Light Co.
P.O. Box 2121, Corpus Christi, Texas *W. J. Tometich*

Champion Lamp Works Div. of Consolidated Electric Lamp Co.
600 Broad St., Lynn, Mass. *Ellery H. Raddin*

Cincinnati Gas & Electric Co.
Fourth & Main Sts., Cincinnati 1, Ohio *J. R. Hartman*

Circlite Corp.
118 So. Clinton St., Chicago, Ill. *George Gomberg*

City of Burbank, California Public Service Dept.
174 W. Magnolia Boulevard, Burbank, Calif. *J. H. McCambridge*

City of Glendale Public Service Dept.
119 N. Glendale Ave., Glendale 6, Calif. *H. E. Gulick*

City of Riverside Electric Light Dept.
3854 Mulberry St., Riverside, Calif. *L. W. Grayson*

City of Seattle, Dept. of Lighting—Puget Sound
1015 Third Ave., Seattle 4, Wash. *P. C. Spowart*

City of Tacoma, Light Division
402 City Hall, Tacoma 2, Wash. *Roy H. Weston*

The Cleveland Electric Illuminating Co.
75 Public Square, Cleveland 1, Ohio *R. C. Hienton*

Clyde Porcelain Steel Corp.
2211 Birdseye St., Clyde, Ohio *W. F. White*

Colonial Premier Corp.
466 W. Superior St., Chicago 10, Ill. *Richard Weis*

Columbia Electric & Mfg. Co.
1024 West Ide Ave., Spokane, Wash. *Walter A. Toly*

Commercial Light Co.
841 W. Washington Blvd., Chicago, Ill. *Michael R. Fine*

Commonwealth Edison Co.
72 W. Adams St., Chicago 90, Ill. *Ralph G. Raymond*

The Connecticut Light & Power Co.
250 Freight St., Waterbury 91, Conn. *Robert G. Ely*

Consolidated Edison Co. of N. Y., Inc.
4 Irving Place, New York 3, N. Y. *C. Miller*

Consolidated Gas, Elec. Light & Power Co. of Baltimore
100 W. Lexington St.,Baltimore 1, Md. *M. C. Albrittain*

Consumers Power Co.
212 Michigan Ave. W., Jackson, Mich. *D. E. Karn*

Consumers Public Power Co.
1452 25th Ave., Columbus, Nebr. *W. H. Sinke*

Corning Glass Works
Corning, N. Y. *A. S. Tylor*

Coyne Electrical School, Inc.
500 So. Paulina St., Chicago 7, Ill. *John Hanan*

Crescent Electric Supply Co.
765 Iowa St., Dubuque, Iowa *Titus B. Schmid*

Crouse-Hinds Co.
Syracuse 1, N. Y. *A. H. Clarke*

Crouse Hinds Co. of Canada, Ltd.
7 Labatt Ave., Toronto, Ont. *F. R. Jeffery*

Curtis Lighting, Inc.
6135 W. 65th St., Clearing Station, Chicago 38, Ill. *Darwin Curtis*

Curtis Lighting of Canada, Ltd.
195 Wicksteed Ave.,Leaside, Toronto 12, Ont. *H. L. Wright*

Cutler Light Manufacturing Co.
2026-28 N. 22d St., Philadelphia 21, Pa. *Robert T. Cutler*

Dallas Power & Light Co.
1506 Commerce St., Dallas 1, Texas *W. G. Moore*

Day-Brite Lighting, Inc.
5401 Bulwer St., St. Louis 7, Mo. *D. J. Biller*

The Dayton Power & Light Co.
25 No. Main St., Dayton, Ohio *H. S. Nonneman*

Dazor Manufacturing Corp.
4483 Duncan Ave., St. Louis 10, Mo. *P. L. Read*

Delaware Power & Light Co.
600 Market St., Wilmington 99, Del. *W. A. F. Fyle*

Dept. of Water & Power, City of Los Angeles, Bur. of Power & Light
Box 3669, Terminal Annex, 207 So. Broadway, Los Angeles 54, Calif. *C. P. Garman*

Detroit Edison Co.
2000 Second Ave., Detroit 26, Mich. *L. E. Tayler*

Detroit Electrical Contractors Association
627-628 Hotel Book Cadillac, Detroit 26, Mich. *Carl J. Schoeniger*

Detroit Steel Products Co.
2250 E. Grand Blvd., Detroit 11, Mich. *W. Clifton Randall*

E. I. duPont de Nemours & Co., Inc. (Fabrics & Finishes Div.)
Wilmington 98, Del. *S. W. Quisenberry*

E. I. duPont de Nemours & Co., Inc. Polychemicals Dept.
Wilmington 98, Del. *R. E. Leary*

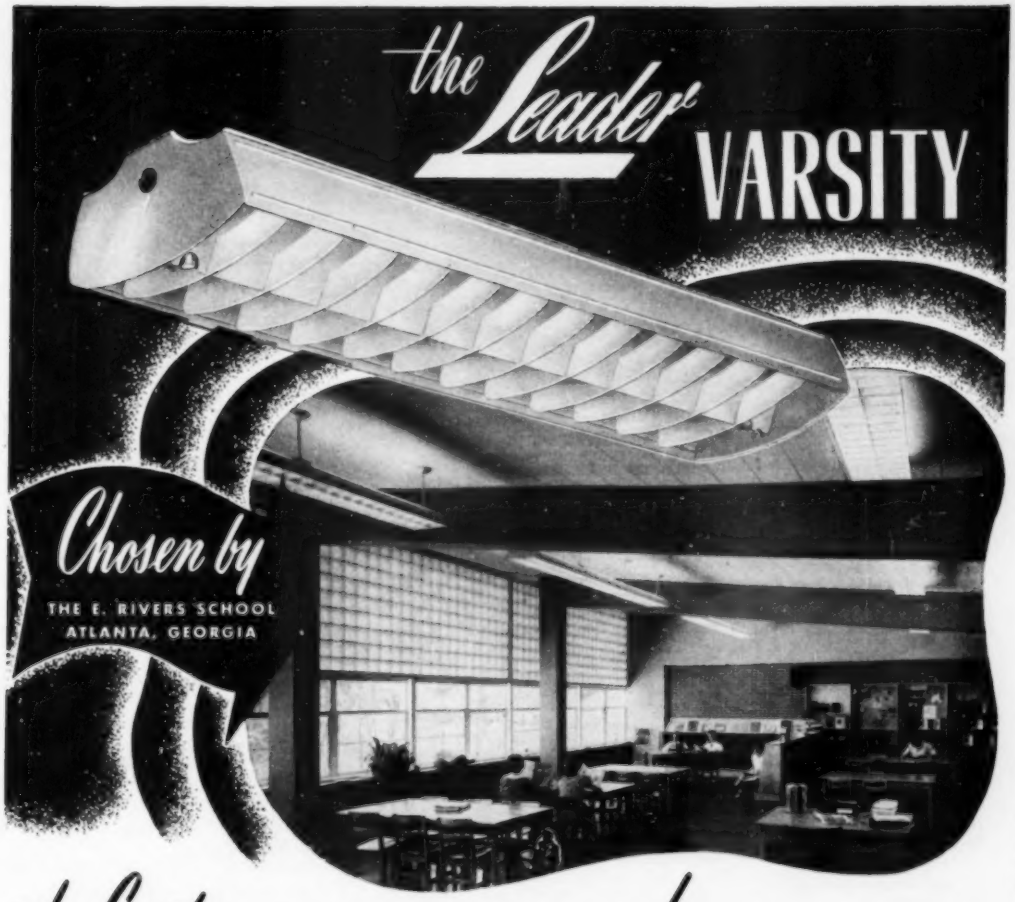
Duquesne Light Co.
435 Sixth Ave., Pittsburgh 19, Pa. *G. W. Ousler*

Duro Test Corp.
2321 Hudson Blvd., North Bergen, N. J. *James L. Cox*

Eastern Fixture Co., Inc.
170 Vernon St., Boston 20, Mass. *Louis Gilman*

(*Continued on page 22A*)

(*Note:* Names of Official Representatives appear in italics.)



to Create IDEAL SEEING CONDITIONS for YOUNG AMERICA

It is only logical that when really important lighting jobs are up for bids . . . architects and contractors look to Leader. That's what happened in the case of the E. Rivers School at Atlanta. Architects Stevens & Wilkinson, and contractors Brittain & Pattillo, agreed that a dual component luminaire was required. The Leader VARSITY was the obvious choice because 60% of its output is directed downward and 40% upward, creating ideal seeing conditions. And VARSITY's economical price runs well within the school budget. . . .

Whatever your next lighting problem may be — classroom, office, library, store, bank, institution or industrial plant — look to Leader and see the logical and profitable answer.

Sold and installed by the better electrical dealers and contractors

Leader *America's No. 1 Lighting Equipment Manufacturer*

LEADER ELECTRIC COMPANY • 3500 North Kedzie Avenue • Chicago 18, Illinois
Leader Electric—Western: 800 One Hundredth Avenue, Oakland 3, California
Campbell-Leader, Ltd.: Brantford, Ontario • Canada

(Continued from page 20A)

East Side Metal Spinning & Stamping Corp.
1301 Elizabeth Ave., W., Linden, N. J.
M. A. Kremer

Ebasco Services, Inc.
2 Rector St.,New York 6, N. Y. *M. E. Stone*

Efongee Electrical Supply Co.
949 W. Chicago Ave., Chicago 22, Ill. *Lee Mirus*

Electrical Information Publications, Inc.
20 N. Carroll St., Madison, Wis. *Lewis E. Johnson*

Electrical Testing Laboratories, Inc.
79th St. & East End Ave., New York 21, N. Y.
W. F. Little

Electric Supply Corporation
701 W. Jackson Blvd., Chicago 6, Ill.
L. B. Mangione

Electro Manufacturing Corp.
2000 W. Fulton St., Chicago 12, Ill.
L. K. Schoenbrod

Electrolier Mfg. Company, Ltd.
5849 Boyer St., Montreal, Que., Canada
John Isenman

Ender Manufacturing Corp.
260 West St., New York 13, N. Y. *Jules Levenstein*

Electron Corp.
5100 South Santa Fe, Littleton, Colo.
Milt Heiner

Englewood Electrical Supply Co.
5801-05 So. Halsted St., Chicago, Ill. *Ray O'Leary*

Fitchburg Gas & Electric Light Co.
557 Main St., Fitchburg, Mass. *A. G. Neal*

Florida Power & Light Co.
Box 3100, Miami 30, Fla. *C. B. Fick*

Fluorescent Equipment & Mfg. Co.
2570 Superior Ave., Cleveland 14, Ohio
Leonard S. Freeman

Fluorescent Fixtures of Calif.
3320 18th St., San Francisco 10, Calif.
Ernst O. Anders

Fluores-O-Lite Co.
Evans Terminal, No. Broad St., Hillside, N. J.
Meyer H. Silverman

The Fostoria Pressed Steel Corp.
Fostoria, Ohio *E. L. Bates*

H. A. Framburg & Co.
3320-28 Carroll Ave., Chicago 24, Ill.
Stanley A. Framburg

The France Mfg. Co.
10525 Berea Rd., Cleveland 2, Ohio *J. H. Mayne*

The Frankelite Co.
1425 Rockwell Ave., Cleveland 14, Ohio
Dave Frankel

Franklin Design Service, Division of Safeway Stores, Inc.
4th & Jackson Sts., P.O. Box 660, Oakland 4, Calif.
Wallace H. Lane

The Frink Corporation
27-01 Bridge Plaza North, Long Island City, N. Y.
Theo. J. Brassel, Jr.

Gallagher-O'Brien Electric Co., Inc.
915 W. North Ave., Chicago 22, Ill.
Frank A. Gallagher

Garden City Plating & Mfg. Co.
1750 No. Ashland Ave., Chicago 22, Ill.
G. G. Harney

General Electric Co., Apparatus Dept.
River Works, 920 Western Ave., West Lynn, Mass.
A. F. Dickerson

General Electric Co., Lamp Dept.
Nela Park, Cleveland 12, Ohio *Willard C. Brown*

General Electric Supply Corp.
1260 Boston Ave., Bridgeport, Conn.
W. W. Booth

General Lighting Products Co.
468 Frelinghuysen Ave., Newark 5, N. J.
Nathan H. Eglowstein

General Outdoor Advertising Co., Inc.
515 So. Loomis St., Chicago, Ill. *R. E. Nevius*

The Georgia Power Co.
Electric Building, Atlanta 1, Ga.
Charles A. Collier

Gibson Manufacturing Co.
1919 Piedmont Circle N. E., Atlanta, Ga.
R. R. Gibson

Gill Glass & Fixture Co.
Amber & Tioga Sts., Philadelphia 34, Pa.
C. A. Gill

Gillinder Brothers, Inc.
Erie & Liberty Sts., Port Jervis, N. Y.
J. Fletcher Gillinder

Gleason-Tiebout Glass Co.
59-50 54th St., Maspeth, N. Y.
Marshall T. Gleason

Globe Lighting Products Co., Inc.
1710 Flushing Avenue, Brooklyn 6, N. Y.
Isidor Rosenblatt

Godfrey and Wing, Inc.
2110 Superior Ave., Cleveland 14, Ohio
C. G. Wing

Golde Manufacturing Co.
1214 W. Madison, Chicago 7, Ill. *E. W. Goldberg*

Grand Rapids Store Equip. Co.
1340 Monroe Ave., N. W.,Grand Rapids 2, Mich.
Kenneth C. Welch

Graybar Electric Co., Inc.
420 Lexington Ave., New York 17, N. Y.
Raymond C. Kinney

Gulf States Utilities Co.
Box 2951, Beaumont, Texas *Clarence Barron*

The Edwin F. Guth Co.
2615 Washington Ave., St. Louis 3, Mo.
Fred E. Guth

The Hankins Container Co.
3044 W. 106th St., Cleveland 11, Ohio
Ray T. White

Hartford Electric Light Co.
266 Pearl St., Hartford 3, Conn. *Victor Ouellette*

Hawkins Electric Co.
1447 Washington Blvd., Chicago 7, Ill. *R. R. Hill*

Hendrickson-Heffernan Co., Inc.
45-17 Pearson St., Long Island City 1, N. Y.
Joseph T. Manuele

Holcombe Co.
2501 Scranton Rd., Cleveland 13, Ohio
H. E. Ingraham

Holophane Company, Inc.
342 Madison Ave., New York 17, N. Y.
H. L. Logan

Home Light and Power Co.
810 Ninth St., Greeley, Colo. *C. Gilbert Dresser*

House-O-Lite Corporation
2430 S. Ashland Ave., Chicago 8, Ill.
Jack R. Stone

Houston Lighting & Power Co.
P.O. Box 1700, Houston 1, Texas *W. J. Aicklen*

Hub Electric Company
2219 W. Grand Ave., Chicago 12, Ill.
I. M. Fixman

Hydro-Electric Power Comm. of Ont.
620 University Ave., Toronto, Ontario
R. L. Hearn

Hyland Electrical Supply Co.
700 West Jackson Blvd., Chicago, Ill. *J. A. Tills*

Illinois Power Co.
134 East Main St., (L Box 511 B), Decatur 70, Ill.
Allen Van Wyck

Illuminating Engineering Co.
2347 E. Nine Mile Road, Hazel Park, Mich.
Bert C. Pretzer

Iowa Electric Light & Power Co.
Box 351, Cedar Rapids, Iowa *Sutherland Dows*

Iowa-Illinois Gas & Electric Co.
United Light Bldg., Davenport, Iowa
John M. Hollingsworth

Iowa Power and Light Co.
312 Sixth Ave., Des Moines 3, Iowa
N. Bernard Gussett

Iowa Public Service Co., East Div.
400 Commercial St., Waterloo, Iowa
C. R. Wagoner

Iowa Public Service Co., Sioux City Division
P.O. Box 778, Sioux City 4, Iowa *C. R. Tracy*

Jeannette Shade & Novelty Co.
N. Fourth St., Jeannette, Pa. *H. N. Crock*

Jefferson Electric Co.
Bellwood, Ill. *L. Maurer*

Jersey Central Power & Light Co.
501 Grand Ave., Asbury Park, N. J. *D. J. Douglas*

Jolcco Corporation
2513 Baldwin St., St. Louis, Mo. *George Ledbetter*

Jones Metal Products Co.
West Lafayette, Ohio *H. Boyer*

Joslyn Mfg. & Supply Co.
3700 So. Morgan St., Chicago 9, Ill. *J. H. Fahey*

Kansas City Power & Light Co.
P.O. Box 679, Kansas City 10, Mo.
John M. Arthur, Jr.

Kansas Gas & Electric Co.
P.O. Box 204, Wichita, Kans. *H. W. Hobson*

The Kayline Company
2480 E. 22d St., Cleveland 15, Ohio *M. A. Eskins*

Kelso-Burnett Electric Co.
225 W. Jackson Blvd., Chicago 6, Ill.
Sigmund A. Hollinger

Kerrigan Iron Works, Inc.
1033 Herman St., Nashville,Tenn. *G. E. Daniels*

Keystone Electric Manufacturing Co.
2228-36 E. Tioga St., Philadelphia 34, Pa.
Leonard M. Siegel

The Kirlin Company
3435 E. Jefferson Ave., Detroit 7, Mich.
Ivan Kirlin

Kopp Glass, Inc.
Swissvale, Pa. *F. C. Asha*

The La Salle Lighting Products, Inc.
145 Seneca St., Buffalo 3, N. Y.
Richard C. Piper, Jr.

Leader Electric Manufacturing Corp.
3500 N. Kedzie St., Chicago 18, Ill. *Walter Glass*

The Leeds & Northrup Co.
4901 Stenton Ave., Philadelphia 44, Pa.
I. M. Stein

Libbey-Owens-Ford Glass Co., Ploskon Division
2112-24 Sylvan Ave., Toledo, Ohio
Dr. M. H. Bigelow

Light Control Company
5217 Casitas Ave., Los Angeles 26, Calif.
Stanley E. Lindahl

(Continued on page 25A)

THE OLD WAY:
strong contrast
deep shadows

the
GUTH WYTE-LINER WAY:
low contrast
soft shadows

Here's a new idea in factory lighting to lift the eyestraining gloom off the ceiling:

ALL WHITE INSIDE—to reflect maximum light down and outward onto the working area.

ALL WHITE OUTSIDE—to reflect room light upward, brighten the ceiling and soften brightness contrast.

Easier to clean—reduces maintenance. Airflow Channel circulates air currents for longer ballast life.

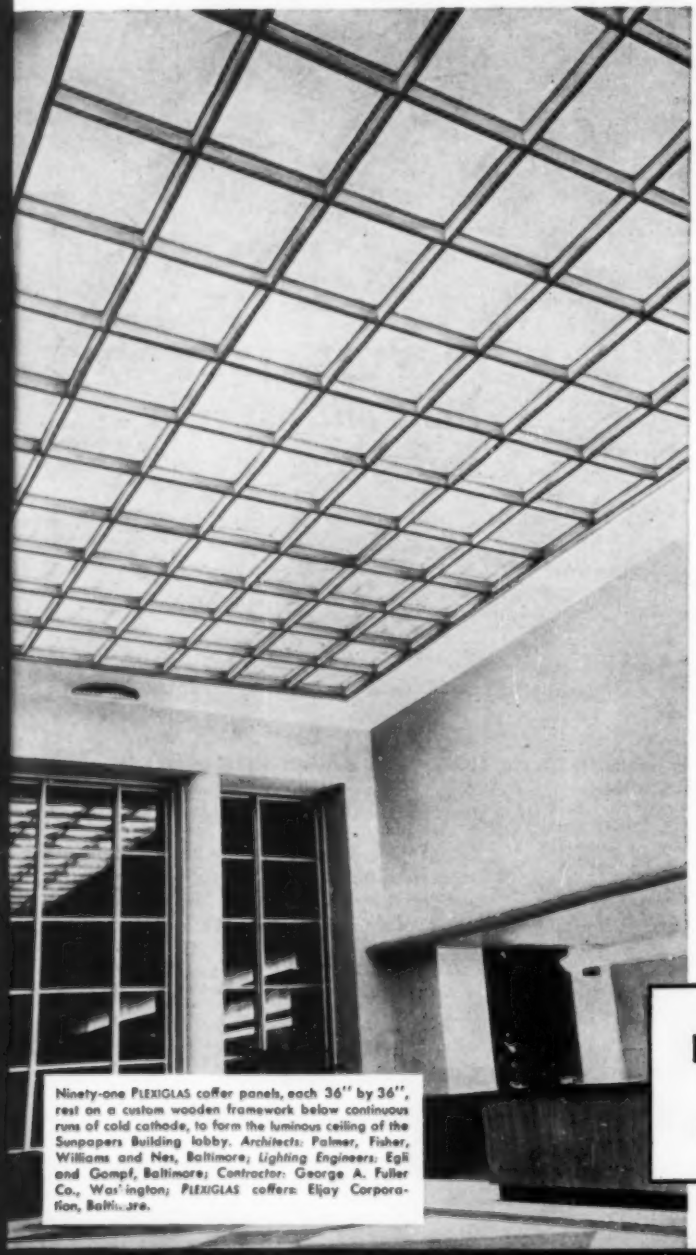
GUTH Wyte-Liners are made in 2 and 3 lamp sizes for conventional 40-watt lamps and for 4- and 8-ft. Slimline. May we send you our 16-page Catalog 48-1 with complete details?

Guth LIGHTING

THE EDWIN F. GUTH COMPANY / ST. LOUIS 3, MISSOURI

Leaders in Lighting since 1902

How a PLEXIGLAS Luminous Ceiling Solved a Design Problem



Ninety-one PLEXIGLAS coffer panels, each 36" by 36", rest on a custom wooden framework below continuous runs of cold cathode, to form the luminous ceiling of the Sunpapers Building lobby. *Architects:* Palmer, Fisher, Williams and Nes, Baltimore; *Lighting Engineers:* Egli and Gompf, Baltimore; *Contractor:* George A. Fuller Co., Washington; PLEXIGLAS coffers: Eljay Corporation, Baltimore.

Problem: To light this spacious, high-ceiling lobby of the new Sunpapers Building in Baltimore, and maintain its clean architectural design. **Solution:** A luminous ceiling of PLEXIGLAS acrylic plastic panels.

With PLEXIGLAS luminous ceilings, lighting becomes an architectural component, not a design afterthought. The white translucent diffusers — corrugated, flat, or formed into three-dimensional shapes—conceal lamps, ducts and pipes *completely*. Yet the output of the lighting source is utilized fully, due to high transmission efficiency. The luminous area overhead is the visible source of light—a lighting fixture as big as a room.

Other advantages: Complete, uniform diffusion; high illumination levels with low source brightness; control of brightness ratios; reduction of glare, shadows, and specular reflection to a minimum; the creation of a luminous environment. And the light weight and strength of PLEXIGLAS give freedom from breakage during installation and maintenance, and safety overhead in service.

Our new booklet—PLEXIGLAS LUMINOUS CEILINGS—outlines design considerations and presents case studies. Write for your copy today.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

PLEXIGLAS *is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.*

Canadian Distributor: Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.

(Continued from page 22A)

Lighting Products, Inc.
2259 W. Park Ave., Highland Park, Ill.
D. E. Dunne

Lightolier Co.
11 East 36th St., New York 16, N. Y. *H. Stollnitz*

Line Material Co., Division of McGraw Electric Co.
800 North 8th St., Milwaukee 1, Wis. *M. C. Harsh*

Litecontrol Corp.
36 Pleasant St., Watertown 72, Mass.
Paul H. Lamson

Lithonia Lighting Products Co., Inc.
Lithonia, Georgia *Robert J. Freeman*

Louisiana Power & Light Co.
142 Delaronde St., Station "A," New Orleans, La.
C. L. Osterberger

Luminator, Inc.
120 N. Peoria St., Chicago 7, Ill.
Albert L. Arenberg

T. R. Lyda Manufacturers Rep.
4922 Washington Blvd., Indianapolis, Ind.
T. R. Lyda

Lynn Gas & Electric Co.
90 Exchange St., Lynn, Mass. *James A. Cool*

Macbeth Corp.
P.O. Box 950, Newburgh, N. Y. *Norman Macbeth*

Malden Electric Co.
157 Pleasant St., Malden, Mass. *Donald S. Bennett*

Markel Electric Products, Inc.
129-14d Seneca St., Buffalo 5, N. Y.
Morris L. Markel

La Cie Martineau Electrique Ltee.
24 rue du Roi, Quebec, Canada *Henri Martineau*

Metalcraft Products Co., Inc.
Masher & Lippincott Sts., Philadelphia 33, Pa.
Nathan Bloom

Metal Window Institute
Cheltenham, Pa. *George Hingston*

Metropolitan Edison Co.
412 Washington St., Reading, Pa.
T. O. McQuiston

Metropolitan Electrical Supply Co.
20 N. Jefferson St., Chicago 6, Ill. *H. J. Privat*

Midwest Chandelier Co.
15th & Gentry Sts., No.Kansas City 16, Mo.
Sidney Lefkovitz

The Miller Co.
Meriden, Conn. *G. W. Beals*

Mississippi Glass Co.
98 Angelica St., St. Louis 7, Mo. *Reed Muir*

Mississippi Power Co.
Gulfport, Miss. *R. M. Shearer*

Mississippi Power & Light Co.
Lampton Building, Jackson, Miss. *Les Taylor*

Mitchell Manufacturing Co.
2525 Clybourn Ave., Chicago 14, Ill.
Bernard Mitchell

Modern Light Company
7809 Maplewood Industrial Court,
Maplewood 17, Mo. *J. E. Baker*

Modern Light & Equip. Co.
3812 S. Wabash Ave., Chicago, Ill.
M. L. Offenberg

Moe-Bridges Corp.
1415 Illinois Ave., Sheboygan, Wis. *M. B Deutsch*

Moe Light, Inc.
700 Oak St., Fort Atkinson, Wis. *Stanley Warner*

Montana-Dakota Utilities Co.
831 Second Ave. So., Minneapolis 2, Minn.
W. L. Hayes

Municipal Light and Power Dept.
City of Pasadena, California, 302 City Hall,
Pasadena 1, Calif. *E. L. Bettannier*

Mutual Sunset Lamp Mfg. Co., Inc.
540 Empire State Bldg., New York 1, N. Y.
Morris Thau

The Narragansett Electric Co.
49 Westminster St., Providence 1, R. I.
C. R. Broadhead

National Chemical & Manufacturing Co.
Luminall Paint Div.
3617 So. May St., Chicago 9, Ill.
John Marshall Ziv

National Lighting Products
4221 W. Harrison St., Chicago 24, Ill. *D. J. Epp*

Nelson-Tombacher Co.
81 Prospect St., Brooklyn, N. Y. *M. J. Tombacher*

New Bedford Gas & Edison Light Co.
693 Purchase St., New Bedford, Mass.
W. S. Fenstermacher

New Orleans Public Service, Inc.
317 Baronne St., New Orleans, La. *S. L. Drumm*

New York State Electric & Gas Corp.
62 Henry St., Binghamton, N. Y.
Earle C. Edwards

Niagara Mohawk Power Corp.
300 Erie Blvd. W., Syracuse 2, N. Y.
Leland D. McCormac

Northern Electric Co. Ltd.
1620 Notre Dame St., West, Montreal, Quebec
F. P. Labey

Northern Indiana Public Service Co.
5265 Hohman Ave., Hammond, Ind.
J. C. Sackman

Northern Light Company
1657 No. Water St., Milwaukee 2, Wis.
Fred Cramer

Northern States Power Co.
Minneapolis 2, Minn. *Carl T. Bremicker*

Ohio Edison Co. (Akron Div.)
Akron 8, Ohio *C. L. Dunn*

The Ohio Power Co.
301-315 Cleveland Ave., S. W., Canton 2, Ohio
C. B. Morin

The Ohio Public Service Co.
P.O. Box 6058, Cleveland 1, Ohio *C. L. Dunn*

Oklahoma Gas & Electric Co.
Box 1498, Oklahoma City 1, Okla. *E. W. Gray*

Omaha Public Power District
720 Electric Bldg., Omaha 2, Nebraska
E. E. Schwalm

Pacific Gas & Electric Co.
245 Market St., San Francisco 5, Calif. *O. R. Doerr*

Pacific Power & Light Co.
522 Public Service Bldg., Portland 4, Oregon
C. A. Root

Peerless Electric Ltd.
1090 Pratt Ave., Outremont, Quebec
L. A. Van Duzer

Pennsylvania Electric Co.
535 Vine St., Johnstown, Pa. *Frank R. Knowles*

Pennsylvania Power Co.
19 E. Washington St., New Castle, Pa.
P. G. Dingledy

Pennsylvania Power & Light Co.
901 Hamilton St., Allentown, Pa. *J. M. Stedman*

Pennsylvania Wire Glass Co.
1612 Market St., Philadelphia 3, Pa.
Dr. Frank W. Preston

The Perfoclite Company
1457 E. 40th St., Cleveland, Ohio
Joseph L. Jaffe, Jr.

Philadelphia Electric Co.
1000 Chestnut St., Philadelphia 5, Pa.
H. B. Bryans

Philadelphia Electrical & Mfg. Co.
1200-36 N. 31st St., Philadelphia 21, Pa.
R. A. Manwaring

Phoenix Glass Co.
Monaca, Pa. *D. G. Cameron*

Pierce Electric Co.
367 W. Adams St., Chicago 6, Ill. *John H. Pierce*

Pittsburgh Corning Corp.
307 Fourth Ave., Pittsburgh, Pa.
Robert W. McKinley

Pittsburgh Plate Glass Co.
Grant Bldg., Pittsburgh 19, Pa. *R. B. Tucker*

Pittsburgh Reflector Co.
405-411 Oliver Bldg., Pittsburgh 22, Pa.
H. C. Zinsmeister

Portland General Electric Co.
Electric Bldg., Portland 5, Ore. *T. W. Fitch*

The Potomac Edison Co.
55 E. Washington St., Hagerstown, Md.
S. S. Bradford

Powerlite Devices, Limited
1870 Davenport Road, Toronto 9, Ont.
M. B. Hastings

Public Service Co. of Colo.
900 Fifteenth St., Denver, Colo. *G. B. Buck*

Public Service Co. of Indiana, Inc.
110 N. Illinois St., Indianapolis 9, Ind.
G. O. Stewart

Public Service Co. of Northern Illinois
72 W. Adams St., Chicago 3, Ill. *G. K. Hardacre*

Public Service Co. of Oklahoma
Box 201, Tulsa 2, Okla. *C. N. Robinson*

Public Service Electric & Gas Co.
80 Park Place, Newark 2, N. J. *H. P. J. Steinmetz*

Puget Sound Power & Light Co.
860 Stuart Bldg., Seattle 11, Wash.
Frank McLaughlin

Quadrangle Mfg. Co.
32 So. Peoria St., Chicago 7, Ill.
Dwight E. Worrell

Quaker City Electric Mfg. Co.
2810 East Pacific St., Philadelphia, Pa.
Reuben Huberman

Quebec Hydro-Electric Commission
107 Craig St., West, Montreal, Que.
Paul E. Poitras

Quebec Power Co.
229 St. Joseph St., Quebec, Que.
Jean Saint-Jacques

Rambusch Decorating Co.
40 W. 13th St., New York 11, N. Y.
Edward Rambusch

Revere Electric Mfg. Co.
6009-17 N. Broadway, Chicago 40, Ill.
Van N. Marker

Revere Electric Supply Co.
757 West Jackson Blvd., Chicago, Ill.
Floyd Fernau

Rochester Gas & Electric Corp.
89 East Ave., Rochester 4, N. Y. *L. C. Twitchell*

Rockland Light & Power Co.
Nyack, N. Y. *D. S. Schaab*

Rohm and Haas Co.
222 W. Washington Sq., Philadelphia 5, Pa.
W. T. Reedy

(Continued on page 26A)

(Continued from page 25A)

Ruby-Philite Corp.
52-02 Queens Blvd., Long Island City 1, N. Y.
Louis Phillips

Rumsey Electric Co.
1007 Arch St., Philadelphia 7, Pa. *T. W. Lauer*

Ryall Electric Supply Co.
1160 Stout, Denver, Colo. *C. O. Ryall*

The Safety Car Heating & Lighting Co.
P.O. Box 904, New Haven 4, Conn. *J. J. Kennedy*

St. Joseph Ry., Light, Heat & Power Co.
520 Francis St., St. Joseph 2, Mo. *F. P. O'Connor*

Sandee Manufacturing Co.
5050 Foster Ave., Chicago, Ill. *Cortes N. Sprankle*

Sandel Manufacturing Co.
3618 So. Loomis Place, Chicago 9, Ill. *A. L. Sandel*

San Diego Gas & Electric Co.
P.O. Box 1831, San Diego 12, Calif.
A. E. Holloway

Savannah Electric & Power Co.
Savannah, Ga. *J. L. Davidson*

Schomer Electric Supply
164 S. Broadway, Aurora, Ill. *Daniel Schomer*

The Albert Sechrist Mfg. Co.
1717 Logan St., Denver 5, Colo. *K. L. Francis*

L. J. Segil Co.
2500 W. North Ave., Chicago, Ill.
Louis Rosenstein

Shawinigan Water and Power Co.
600 Dorchester St., W., Montreal, Que.
J. K. Wilson

The Sherwin-Williams Co.
101 Prospect Ave., N. W., Cleveland 1, Ohio
J. A. Meacham

The Sight Light Corp.
P.O. Drawer C, Deep River, Conn. *E. L. Canfield*

Silvray Lighting, Inc.
R.K.O. Bldg., Radio City, New York 20, N. Y.
J. M. Gilbert

Smithcraft Lighting Division
A. L. Smith Iron Company
217 Everett Avenue, Chelsea 50, Mass.
Hugh M. Nazor

Smoot-Holman Co.
321 No. Eucalyptus Ave., Inglewood, Calif.
L. A. Hobbs

Sola Electric Co.
4633 W. 16th St., Chicago 50, Ill. *L. C. Marschall*

Solar Light Mfg. Co.
1357 S. Jefferson St., Chicago 7, Ill. *A. Lazerson*

The Solex Co. Ltd.
280 Faillon St.,West, Montreal, Que.
Leon Beauchamp

Southern Calif. Edison Co., Ltd.
601 West 5th St., Los Angeles 53, Calif.
Roy E. Dahlin

Southern Canada Power Co., Ltd.
355 James St., West, Montreal, Que.
George R. Atchinson

Southern Colorado Power Co.
Box 75, Pueblo, Colo. *E. H. Pemberton*

Southern Indiana Gas & Elec. Co.
P.O. Box 569, Evansville 5, Ind. *C. K. Graham*

Southern Lighting Mfg. Co.
P.O. Box 2546, Orlando, Fla. *Max K. Aulick*

Southwestern Gas & Elec. Co.
Box 1106, Shreveport, La. *J. E. Elliott*

Southwestern Public Service Co.
Amarillo, Texas *J. E. Cunningham*

Stanley Electric Mfg. Co.
8001 Laycock St., Philadelphia 42, Pa.
Bernard S. Heller

Steber Manufacturing Co.
2700 Roosevelt Rd., Broadview, Maywood, Ill.
Robert J. Besal

Steiner Electric Co.
3500 Milwaukee Ave., Chicago 41, Ill.
George S. Steiner

Sterling Reflector & Mfg. Co.
3249 West Grand Ave., Chicago 51, Ill.
Anton Oberhuber

Stonco Electric Products Co.
489 Henry St., Elizabeth 4, N. J. *J. W. Spence*

Sunbeam Lighting Co.
777 E. 14th Place, Los Angeles 11, Calif.
Herbert L. Krieger

Sun-Lite Manufacturing Co.
2555 Bellevue Ave., Detroit 7, Mich. *Fred Binder*

Sun-Ray Fluorescent Co.
2025 South Michigan Ave., Chicago, Ill.
Jerome Gimbel

Sylvania Electric Products, Inc.
1740 Broadway, New York 19, N. Y. *D. P. Caverly*

Tampa Electric Co.
Cass & Tampa Sts., Tampa 1, Fla. *F. J. Gannon*

Frank C. Teal Co.
3222-24 E. Jefferson, Detroit 7, Mich.
Harold C. Smith

Texas Electric Service Co.
Electric Bldg., Fort Worth 1, Texas
R. E. Hendricks

Thompson Electric Co.
1101 Power Ave., N. E., Cleveland 14, Ohio
Thayer B. Farrington

Thompson-Wilson Company
737 Spring St., N. W., Atlanta, Ga.
Thomas A. Willis

Toledo Edison Co.
Edison Bldg., Toledo 4, Ohio *Charles A. Harrison*

Toronto Hydro-Electric System
14 Carlton St., Toronto 2, Ont. *A. W. J. Stewart*

Torstenson Glass Co.
3253 N. Sheffield Ave., Chicago 13, Ill.
Elmer L. Torstenson

Triangle Industries
600 W. Adams St., Chicago, Ill. *Leonard Cohen*

Tri-Part Mfg. Company
934 Plum St., Detroit 1, Mich. *Julius Reznik*

Tristate Electrical Supply Co., Inc.
38 S. Potomac St., Hagerstown, Md.
Robert A. Stott

Tru-Lite Ltd.
824 Notre Dame St., W., Montreal, Que.
Omer M. Trudel

Underwriters' Laboratories, Inc.
207 E. Ohio St., Chicago 11, Ill. *Ferd. Neumer*

Union Electric Co. of Missouri
12th & Locust Sts., St. Louis 1, Mo. *W. L. Berry*

Union Metal Mfg. Co.
Canton 5, Ohio *W. A. Porterfield*

Unistrut Corp.
4118 Monroe Ave., Wayne, Mich.
James W. Allwood

Unistrut Products Company
1015 West Washington Blvd., Chicago 7, Ill.
George W. Butler

The United Illuminating Co.
80 Temple St., New Haven 6, Conn. *E. B. Haskell*

United Manufacturing Co.
Div. United Advertising Corp.
190 Whalley Ave., New Haven, Conn.
William R. Harris

Utah Power & Light Co.
Box 899, Salt Lake City 10, Utah *W. A. Huckins*

Verd-A-Ray Corp.
615 Front St., Toledo 5, Ohio *O. S. Levi*

John C. Virden Co.
6009-6105 Longfellow Ave., Cleveland 3, Ohio
W. G. Sawyer

John C. Virden, Ltd.
19 Curity Ave., Toronto, Ont. *P. G. Kirkpatrick*

Virginia Electric & Power Co.
Richmond, Va. *J. G. Holtzclaw*

Voigt Co.
1649 No. Broad St., Philadelphia 22, Pa.
C. J. Frank

The F. W. Wakefield Brass Co.
Vermilion, Ohio *A. F. Wakefield*

Warren Electric Co.
P.O. Box 2594, Houston, Texas *J. R. Thompson*

The Washington Water Power Co.
P.O. Drawer 1445, Spokane 6, Wash.
Carl L. Hoffman

The Watson Standard Co.
225 Galveston Ave., Pittsburgh 12, Pa.
H. E. Striker

Welsbach Engineering and Management Corp.
1500 Walnut St., Philadelphia 2, Pa. *H. H. Adams*

Westinghouse Electric Corp.
1216 W. 58th St., Cleveland 1, Ohio (P.O. Box 5817) *W. F. White*

Westinghouse Electric Supply Co.
113 North May St., Chicago 7, Ill. *Henry Czech*

Westinghouse Lamp Div.
Bloomfield, N. J. *Samuel G. Hibben*

West Penn Power Co.
14 Wood St., Pittsburgh 30, Pa. *Harry Restofski*

Wheeler Reflector Co.
275 Congress St., Boston 10, Mass. *K. A. Sawin*

Wiedenback-Brown Co., Inc.
111 Eighth Ave., New York 11, N. Y.
W. C. Stockberger

R. & W. Wiley, Inc.
119 Dearborn St., Buffalo 7, N. Y.
Robert C. Graves

H. E. Williams Products Co.
108 S. Main St., Carthage, Mo. *F. B. Williams, Jr.*

Wilmot Castle Co.
1255 University Ave., Rochester 7, N. Y.
E. H. Greppin

J. A. Wilson Lighting & Display Ltd.
280 Lakeshore Rd., Toronto 14, Ont. *J. A. Wilson*

The Windsor Utilities Comm., Hydro Div.
149 Chatham St., W., Windsor, Ont. *W. A. Shaw*

The Wiremold Company
Hartford 10, Conn. *D. Hayes Murphy*

Wisconsin Electric Power Co.
Public Service Bldg., Milwaukee 1, Wis.
G. W. Van Derzee

Wisconsin Power & Light Co.
122 W. Washington Ave., Madison 1, Wis.
J. D. Howard

Wisconsin Public Service Corp.
Green Bay, Wis. *A. G. Burr*

Worcester County Electric Co.
11 Foster St., Worcester, Mass. *Fred E. Littlefield*

LIGHTING EFFICIENCY

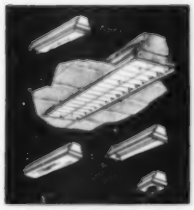
35° crosswise, 41° lengthwise shielding combined with high utilization.

Choose THE NEW 5500 SERIES GARCY recessed troffers

...because of these "ENGINEERED-IN" features

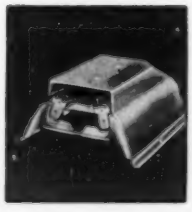
ONE PIECE LOUVER

Punched and formed in one piece with continuous outer frame for lasting rigidity. New, simplified hinging reduces maintenance.



VERSATILITY

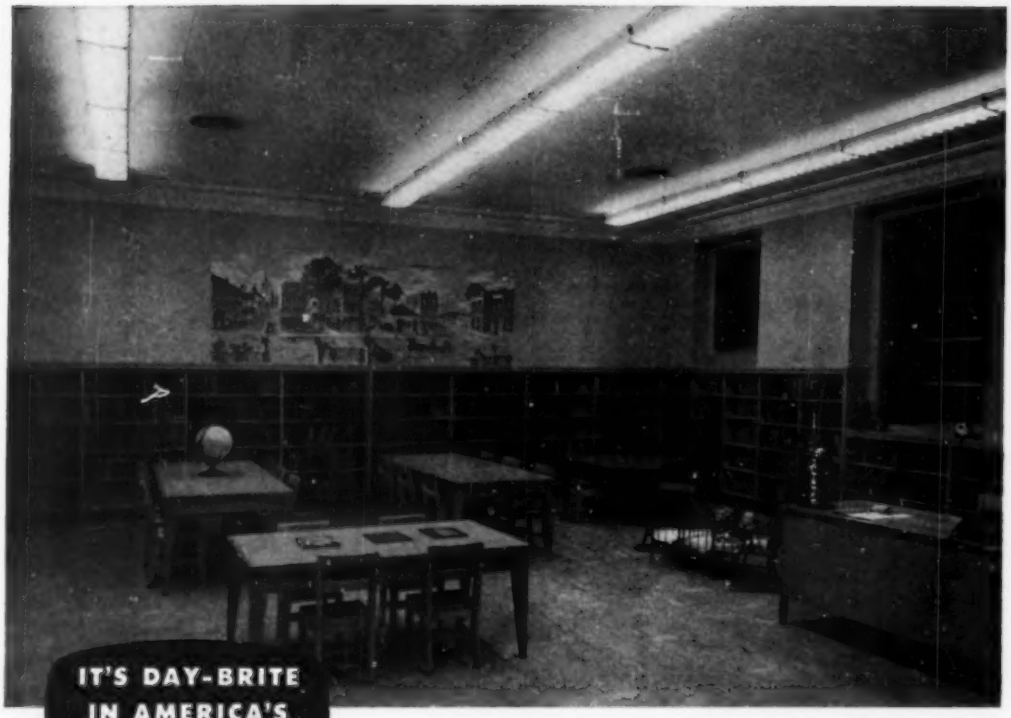
- For any type ceiling.
- 1, 2 or 3 lamp rows.
- 4, 6 or 8 ft. lengths.
- Standard fluorescent or slimline.
- Varied bottom treatments, including louvers, diffusing glass, flat or curved lenses.
- Matching Spot-a-Lites available.



UNIQUE COUPLING PLATE

- Lets light pass from one unit to next for more uniform brightness throughout the run.
- Wide open wireway for fast splicing.
- Simple, bolt-together coupling.

GARDEN CITY PLATING and MFG. COMPANY
1760 North Ashland Avenue
CHICAGO 22, ILLINOIS



This is the Children's Department of the Bradley Memorial Library, Columbus, Ga.

Here's Better Lighting for Better Learning

Throughout America, teachers, school principals and Public School Systems are becoming aware of the school-lighting problem. They have discovered that either sun glare or bright reflected light on shiny wall or blackboard surfaces cause eyestrain. They have learned that sharp color contrasts or too dark rooms bring about nervous tension, retarded learning — may permanently damage young eyes.

When they found out that Day-Brite has conducted exhaustive scientific research on school lighting, hundreds of school officials asked Day-Brite for advice—and purchased Day-Brite fixtures to give them the soft, evenly distributed light of adequate intensity that every classroom needs. Day-Brite's success in American schools is based on quality—the kind of quality that offers modern lighting, years of trouble-free service, low-cost installation and maintenance. Would you like complete details? Write Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis, Mo.

144

NOW, MORE THAN EVER

AMERICA MUST SEE WHAT IT'S DOING

IT'S EASY TO SEE WHEN IT'S

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

NEW JEFFERSON SERIES SEQUENCE BALLAST

254-511 BALLAST—430 MA—118 Volt, 60 Cycle

Approved by Underwriters' Laboratories, Inc.

CERTIFIED

Meets All Requirements of the Proposed American Standard Association Test Specification C82.1

For *Improved Operation* of Two 96T12 Fluorescent Lamps in Series

The new Jefferson Ballast for 96T12 Lamps is compact, lighter weight, quiet, and cool operating. The unique new design assures longer ballast life, greater lamp life, and better all around fixture performance and user satisfaction. ***POSITIVE STARTING**—even at voltages as low as 106 Volts—with no detrimental effect to lamp life.*

UNIQUE DESIGN INSURES RATED LAMP LIFE AND LIGHT OUTPUT

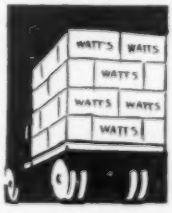
Over 35 years of specialized research engineering, and transformer manufacture has resulted in a unique basic design which assures maximum light output, full rated lamp life, and no noticeable variations in brilliancy of the two lamps.

COOL AND HEALTHY

With full wattage delivered to the lamps, the temperature of the Jefferson Ballast remains low—well within the A.S.A. limits for temperature rise. A cool ballast means long healthy ballast life and better lamp performance.

FULL RATED WATTAGE DELIVERED—LOWER LOSS

Maximum wattage is delivered to both lamps, yet ballast operating temperature is held to a minimum. Results are unlimited ballast life and greater lamp brilliance. Efficiency is indicated by a wattage loss of only 29 watts.



NO HUM TO BOTHER YOU

Here again unique design and construction features along with traditional Jefferson manufacturing skill eliminates audible hum.

Write for your free copy of Bulletin 551-11 describing and illustrating the New Jefferson Series Sequence Ballast.

JEFFERSON ELECTRIC COMPANY • **Bellwood, Illinois**

In Canada: Canadian Jefferson Electric Co., Ltd., 384 Pape Ave., Toronto, Ont.

MEMBER, CERTIFIED BALLAST MANUFACTURERS

"Light Conditioning" is high-spot of National Home Week exhibits!

IN MINNEAPOLIS!

Light Conditioning Used in 12 out of 18 NHW Homes

During National Home Week in Minneapolis, 18 homes were placed on display by Minneapolis builders. Of these, 12 were Light Conditioned.

Builder says Light Conditioning is Sales Advantage!

Robert Bedney, prominent Minneapolis builder, says: "Light Conditioning brought out the real beauty and individuality of my National Home Week home—especially at night. From now on, I want my houses to be Light Conditioned all the way through. It is a real selling advantage."

ELECTRIC SERVICE COMPANY PLAYS BIG ROLE

National Home Week — and Light Conditioning—were strongly promoted by Northern States Power Company, through radio, TV, give-away Light Conditioning booklets, window displays, and on-the-spot demonstrators in the homes.

IN MILWAUKEE!

Light Conditioning Draws Triple-Size Crowds

In Milwaukee, builders and the Wisconsin Electric Power Co., sponsored "Parade of Homes" during National Home Week. In one group of homes, three were Light Conditioned, seven were not. The Light Conditioned homes attracted an average of *three times* as many visitors as the normally-lighted homes.

STOPS VISITORS!

A leading Milwaukee builder, Alfonse Zielinski, says: "I noticed that Light Conditioning stopped the visitors to our home. In past years, frankly, nobody even looked at the lighting. Light Conditioning, especially lighted valances, will certainly be in the plans for my future homes."

BUILDERS GET IDEAS!

Among the most interested visitors to Light Conditioned homes were builders of *non*-Light Conditioned homes. After seeing Light Conditioning, many expressed intentions of Light Conditioning their homes in the future.

IN DETROIT!

LIGHT CONDITIONING MAKES FRONT PAGE

Highlighting the interest and importance of Light Conditioning, the Detroit Free Press featured the Light Conditioned Home on the front page of its special Sunday Home Week section.

Builder and Electric Service Company are Light Conditioning Team

Both the Detroit Edison Company and Miller Homes Company promoted Light Conditioning during National Home Week in Detroit. Miller Homes ran a half-page ad featuring "Planned Lighting." Detroit Edison assisted in selecting lighting equipment, supplied demonstration personnel, distributed Light Conditioning recipe books.

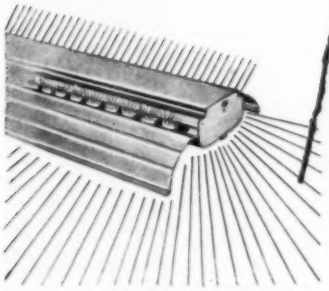
Recipe Book Cooks Up Sale!

The supplier of the fixtures for Detroit's Light Conditioned home reports that a woman walked into his store with a copy of the Light Conditioning recipe book and asked for a duplicate set ($409 worth) of the fixtures she had seen in the demonstration home.

For help in promoting Light Conditioning in *your* community, write—
Lamp Division, General Electric Company, Nela Park, Cleveland 12, Ohio.

GENERAL ELECTRIC

it's new!



New apertured-top reflectors, minimize brightness contrast — give sufficient up-light for overhead maintenance.

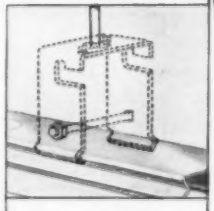
miller 50 FOOT CANDLER JR.

ONE fixture giving TWO-WAY light

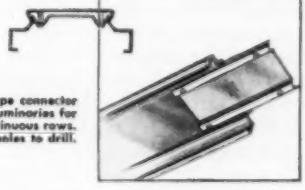
A distinct advance in industrial lighting. Good DOWN-light for overall lighting of industrial areas for maximum production efficiency. *Plus* UP-light through new apertured-top reflectors. More compact — uses new small cross-section ballast. Constructed with a minimum of critical material. Built on Miller's 8-Point QUALITY standard, for long dependable service, easy installation, and low maintenance. Can be installed individually or in continuous rows. Deliveries scheduled to the requirements of defense production.

Miller is one source of supply for QUALITY equipment for the best use of Fluorescent, Incandescent and Mercury lamps. Miller field engineers and distributors are conveniently located for nation-wide service. *Write or wire for complete details.*

New small cross-section G.E. #89G343 ballast — streamlined wireway.



Flanged-top wireway channel permits clamp hanger mounting anywhere along entire length — simplifies installation.



New pressure-type connector for joining luminaries for continuous rows. No holes to drill.

New all-white finish — baked enamel — RLM porcelain enamel.

THE miller COMPANY MERIDEN, CONN.
SINCE 1844

ILLUMINATING DIVISION: Fluorescent, Incandescent, Mercury Lighting Equipment
HEATING PRODUCTS DIVISION: Domestic Oil Burners and Liquid Fuel Devices
ROLLING MILL DIVISION: Phosphor Bronze and Brass in Sheets, Strips and Rolls

NOW! G-E BALLASTS ARE SOUND RATED*

***SOUND-RATING: G. E.'s new classification of ballasts to guide you in the correct application of fluorescent fixtures.**

HOW G-E SOUND RATING WORKS

IF THIS IS YOUR APPLICATION . . .	. . . AND YOUR AVERAGE AMBIENT NOISE LEVEL IS HERE* . . .	USE A BALLAST WITH THIS SOUND RATING
Broadcast Studio Church Country Residence	20-24 decibels	A
Evening School City Residence Quiet Office	26-30 decibels	B
Average Residence Public Library Study Hall	32-36 decibels	C
Classroom Professional Office	38-42 decibels	D
Noisy Residence Business Office	44-48 decibels	E
Store Noisy Office Factories	50-62 decibels	F

**Average ambient noise levels in decibels, measured with standard 40-decibel weighting network.*

A new tool to help you build greater customer satisfaction by minimizing noise complaints

Every fluorescent ballast has a normal, magnetic hum. But now, for the first time, you can know the relative sound level of the ballast before you buy. For G-E engineers have pioneered a system for measuring ballast sound levels accurately. These measurements have led to six classifications: from "A"—extremely quiet, to "F"—quite audible. This means that you know, before installation, which ballasts are right for any given application—whether it be church, school, noisy factory area, or any one of a wide range of other locations.

Take the first step toward eliminating customer complaints about objectionable noise. Write for GEA-5672, a four-page bulletin which explains Sound Rating in detail. A reprint of recent technical information (GER-366) is also available. Write Section 412-93, *General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

412-93

(*Continued from page 19A*)

Kreitzberger, H. J., Pennsylvania Power & Light Co., Hazleton, Pa.
Rimmer, E. F., Pennsylvania Power & Light Co., Wilkes Barre, Pa.

Associate Member:

Buckner, L. O., Metropolitan Edison Co., York, Pa.

Florida Chapter

Associate Member:

Wackerle, C. L., Florida Power & Light Co., Sarasota, Fla.

Foreign Non-Section

Associate Members:

Carenzi, Mario, Selenia, Industria Lampade Fluoruminescenti, Via Francesco Nullo N. 6, Milano, Italy
Falk, Gerald, Planned Lighting Co., 170 Clarence St., Sydney, NSW, Australia
Gianoli, H., Escuela Militar de Chorrillos, Av. Espana 318, Lima, Peru
Tanishika, Mitsuharu, Tokyo Denryoku Kabushiki Kaisha, 1-chome No. 1-2, Shiba Tamura-cho, Minato-ku, Tokyo, Japan
Vasta, Francesco, Icar-Lambda Ltd., Gambaro 8, Rome, Italy

Georgia Section

Member:

Reeves, W. T., Moore Handley Handware Co., Inc., Birmingham, Ala.

Associate Member:

Lundstrom, A. H., Westinghouse Electric Supply Co., Atlanta, Ga.

Hamilton Ontario Chapter

Associate Member:

Greenhough, A. A., Canadian Westinghouse Co., Ltd., Hamilton, Ont.

Indiana Chapter

Member:

Menke, W. W., Purdue University, W. Lafayette, Ind.

Associate Member:

Fitch, J. M., Protective Electric Supply Co., Ft. Wayne, Ind.

Inland Empire Chapter

Associate Members:

Adams, J. W., The Washington Water Power Co., Lewiston, Idaho
Lowry, W. A., Washington Water Power Co., Coeur d'Alene, Idaho

Student Member:

Michaelis, A. J., P. O. Box 295, Dayton, Wash.

Iowa Section

Associate Member:

Mann, R. E., Sylvania Electric Products, Inc., Des Moines, Iowa

Michigan Section

Member:

Palmer, R. J., The Detroit Edison Co., Detroit, Mich.

Associate Member:

Roshak, A. B., Detroit Edison Co., Detroit, Mich.

Milwaukee Section

Associate Members:

Haydak, M. J., Jr., Northern Light Co., Milwaukee, Wis.
Heesch, H. H., Park Electric Co., Milwaukee, Wis.
Schoen, A. G., State of Wisconsin, Milwaukee, Wis.
Schultz, B. H., Line Material Co., S. Milwaukee, Wis.

New England Section

Associate Members:

Boule, G. O., Jr., General Electric Co., Boston, Mass.
Brown, R. F., Noma Electric Corp., New York, N. Y.
Kates, M. I., 17 Prospect St., Cambridge, Mass.
Lait, H. H., General Electric Co., Lynn, Mass.
Moore, J. P., U. S. Navy Yard, Portsmouth, N. H.
Wetmore, C. I., Electro Mfg. Co., Boston, Mass.

New Orleans Section

Associate Members:

Campbell, J. L., New Orleans Public Service, Inc., New Orleans, La.
Scheinuk, L. S., Lighting Fixture & Electric Supply Co., New Orleans, La.
Stouse, P. J., Jr., EACO, Inc., New Orleans, La.

New York Section

Associate Members:

Decew, R. E., 290 Claremont Ave., Mt. Vernon, N. Y.
Florence, N. S., Lightolier, Inc., Jersey City, N. J.
Gluck, E. L., Holophane Co., Inc., New York, N. Y.
Kettyle, J. W., General Electric Co., New York, N. Y.
Meyers, A. L., Columbia University, New York, N. Y.
Mostehedi, Taher, Westinghouse International Electric Co., New York, N. Y.
Neufeld, Harry, Ruby Lighting Co., Long Island City, N. Y.
Paden, E. G., Duro Test Corp., No. Bergen, N. J.

(*Continued on page 34A*)

NEW I.E.S. MEMBERSHIP ROSTER

Every I.E.S. member needs a personal copy of this new 120-page roster of over 6000 names, company connections and addresses. Invaluable for your own and your associates' use in locating fellow members the world over. Sturdily bound for steady use. Postpaid; $2.00 per copy, $1.75 in lots of 10 or more.

Use the coupon for easy ordering today.

PUBLICATIONS OFFICE
ILLUMINATING ENGINEERING SOCIETY
1860 BROADWAY, NEW YORK 23, N. Y.

Send ( ) copy(s) of New I.E.S. Membership Roster to

$ ( ) to address below.

Name _____

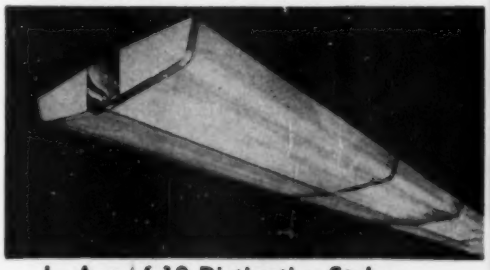
Company _____

Street _____

City _____ Zone ____ State _____

☐ Check enclosed ☐ Bill me

MILWAUKEE ALBA HI-LITE



In Any of 10 Distinctive Styles . . .

the new Alba Hi-Lite will complement the architect's finest interiors . . . of banks, board rooms, executive offices, specialty shops, private clubs, restaurants, or institutions.

For beauty of simplicity . . . ***bent*** Alba-Lite—uncluttered by frameworks, cleared of half the usually used stems.

For life and punch . . . ***ribbed opal*** Alba-Lite, comfortable surface brightnesses, above average lumens per watt.

Surface or ***pendant, alone*** or ***in lines,*** 2- or 4-lamp, 2- 4- 6- or 8-foot lengths, for ***any*** lamp or ballast. ***Easy*** to lay out. ***Easy*** to hang. ***Easy*** to maintain.

Write for Engineering Bulletin B-121, General Specs B-122, Individual Specs B-123, Performance Data B-124, Applications B-125 et seq.

NORTHERN LIGHT COMPANY
MILWAUKEE

(Continued from page 33A)

Slavin, Julius, Road-Ad Service, Inc., Asbury Park, N. J.
Uttal, J. A., General Electric Co., New York, N. Y.
Wilson, D. V., General Electric Co., New York, N. Y.

NORTHERN CALIFORNIA SECTION

Associate Members:

Howard, Jerry, Pacific Gas & Electric Co., San Francisco, Calif.
Morando, T. C., Central Electric Co., San Francisco, Calif.
Wider, F. E., Electrical Maintenance & Service Co., San Francisco, Calif.

Student Member:

Abou-Taleb, N. M., Stanford University, Stanford, Calif.

NORTHWESTERN OHIO CHAPTER

Members:

Ruehlin, W. H., Electric Auto Lite, Toledo, Ohio
Winkeljohn, E. A., Westinghouse Electric Supply Co., Toledo, Ohio

Associate Member:

Gross, R. J., Gross Electric Co., Toledo, Ohio

OHIO VALLEY SECTION

Student Member:

Gronotte, R. H., Jr., University of Dayton, Dayton, Ohio

OREGON SECTION

Member:

Johnson, H. S., Portland General Electric Co., Portland, Ore.

Associate Members:

Boynton, R. M., Stubbs Electric Co., Portland, Ore.
Henderson, G. W., P. O. Box 68, Newport, Ore.
Jennings, G. S., 426 Medical Center Bldg., Medford, Ore.
Keep, R. J., General Electric Co., Portland, Ore.

Student Members:

Clark, A. L., Pacific University, Forest Grove, Ore.
Cobern, G. E., 233 S. 6th Ave., Hillsboro, Ore.
Feinberg, S. J., Pacific University, Forest Grove, Ore.
Hamm, D. C., Pacific University, Forest Grove, Ore.
Nelson, V. H., Pacific University, Forest Grove, Ore.
Wilson, S. J., Pacific University, Forest Grove, Ore.

PHILADELPHIA SECTION

Associate Members:

Hopkin, A. W., Hopkin Bros, Inc., Philadelphia, Pa.
Rogers, R. H., General Electric Co., Philadelphia, Pa.

PITTSBURGH SECTION

Associate Members:

Mullen, W. F., Penna Slate Producers Guild, Pen Argyl, Pa.
Salmon, F. P., Chas. T. G. Provan, Wilinsburg, Pa.

PUGET SOUND SECTION

Member:

Scharr, F. C., 441 Dexter Horton Bldg., Seattle, Wash.

Associate Members:

Kornmesser, R. L., 106 E. 4th Ave., Olympia, Wash.
McKinney, W. J., 232 3rd St., Raymond, Wash.

Student Member:

Kirk, F. N., 9053 53rd S., Seattle, Wash.

ROCKY MOUNTAIN SECTION

Student Member:

Leffler, Fred, Schockett Electric Co., Denver, Colo.

ST. LOUIS SECTION

Member:

Gornet, J. E., Day Brite Lighting, Inc., St. Louis, Mo.

Associate Members:

Church, C. E., Barrett Electrical Supply Co., St. Louis, Mo.
Nieburg, G. C., DayBrite Lighting, Inc., St. Louis, Mo.
Smith, H. M., Fruin Colnon Contracting Co., St. Louis, Mo.

SAN JACINTO SECTION

Associate Member:

Harris, Sumner, Sylvania Electric Products, Houston, Texas

SOUTHEAST FLORIDA CHAPTER

Associate Members:

Fay, G. H., 2635 Hilola St., Miami, Fla.
Glazer, Leonard, Rader Engineering Co., Miami, Fla.
Minor, Lee, Triangle Electric Mfg. Co., Inc., Miami, Fla.

(Continued on page 36A)

descriptive redundancy . . . we'd rather describe this new Sunbeam (#L1280) series in terms that can be supported by extensive photometric and installation experience. Designed for low brightness (.6c/sq." within the shielded zone) and high efficiency (82%) this series is available in all lamp lengths and milliamp ratings . . . write for literature.

something better HAS COME TO school lighting

PITTSBURGH PERMAFLECTOR

FLUORESCENT
INCANDESCENT

Pittsburgh Permaflector

LIGHTING
EQUIPMENT

HILLCREST SCHOOL, Upper Darby, Pa.
Architect: Barney & Boswell
Engineer: Parson, Klotz & Fuller
Elec. Contr.: Electro Construction Co.

THIS BOOKLET

TELLS THE STORY

If you want to know how to plan good lighting for every classroom use, write for this valuable booklet.

PITTSBURGH REFLECTOR COMPANY

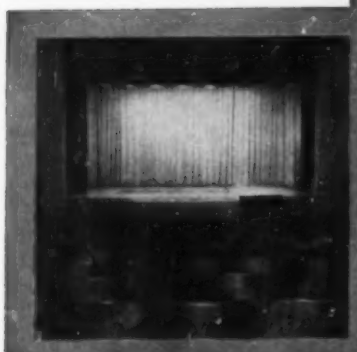
411 OLIVER BUILDING • PITTSBURGH 22, PENNSYLVANIA

MANUFACTURERS OF FLUORESCENT & INCANDESCENT LIGHTING EQUIPMENT

Permaflector Lighting Engineers in All Principal Cities

PITTSBURGH PERMAFLECTOR LIGHTING EQUIPMENT IS DISTRIBUTED BY BETTER ELECTRICAL WHOLESALERS EVERYWHERE

SHAW High School
Cleveland, Ohio



MOTOR-DRIVEN POWERSTAT DIMMERS

CONSOLE-TYPE POSITIONER CONTROL BOARD

THE **LUXTROL** SYSTEM *of lighting control* **FOR ASSEMBLY HALLS**

MINIATURE DIMMER STATIONS CONTROL HIGH WATTAGE LOADS

In assembly halls everywhere — in schools like Cleveland's Shaw High School shown above, and in churches, theatres and organizations of all kinds where people gather — the LUXTROL System of lighting control offers the ultimate in light dimming equipment. The LUXTROL System consists of one or more miniature positioner stations controlling one or more motor-driven POWERSTAT Dimmers. Lights can be dimmed, brightened and blended from conveniently located selector stations with the motor-driven POWERSTAT Dimmers installed in any out-of-the-way area saving valuable space. The compactness of the positioning device allows console-type operation as employed in the Shaw High School. A complete switchboard, with mastering and grand-mastering arrangements, can be mounted in a small cabinet or table — with all controls accessible to the operator. It is, in effect, a large interlocking switchboard in miniature. Complete programs can be set in advance and at set time intervals, switches actuated to concur with performances.

SEND FOR BULLETIN D951L ON THE LUXTROL SYSTEM OF LIGHTING CONTROL

THE SUPERIOR ELECTRIC CO. SEC
BRISTOL, CONNECTICUT

5111 DEMERS AVENUE, BRISTOL, CONNECTICUT

(Continued from page 34A)

SOUTHERN CALIFORNIA SECTION

Members:

Hendrix, Ross, 1516 W. Thomas Rd., Phoenix, Ariz.
Whitnell, J. D., Central Arizona Light & Power Co., Phoenix, Ariz.

Associate Members:

Imhof, E. J., Manufacturers Marketing Service, Los Angeles, Calif.
Kennedy, J. E., Southern California Edison Co., Pomona, Calif.
Parker, C. C., Westinghouse Electric Corp., Phoenix, Ariz.
Thompson, J. B., Grayco Products, Phoenix, Ariz.
Tweedy, R. E., Westinghouse Electric Supply Co., Phoenix, Ariz.

SOUTHWESTERN SECTION

Member:

McCoy, J. E., Oklahoma Gas & Electric Co., Muskogee, Okla.

Associate Members:

Baum, C. E., Westinghouse Electric Corp., Tulsa, Okla.
Burns, J. E., Sylvania Electric Products, Inc., Ft. Worth, Texas
Johnson, J. B., Cummins Supply Co., Ft. Worth, Texas
Prag, E. R., 2241 N. W. 17th St., Oklahoma City, Okla.
Schisler, J. J., Arthur G. McKee & Co., 2303 W. 40th St., Tulsa, Okla.
White, J. H., Felco Products, Inc., Dallas, Texas

TENNESSEE VALLEY CHAPTER

Associate Members:

Maxwell, W. H., General Electric Supply Corp., Paducah, Ky.
Proctor, J. B., General Electric Supply Corp., Memphis, Tenn.

TORONTO SECTION

Member:

Kidd, J. A. I., Canadian General Electric Co., Ltd., Toronto, Ont.

Student Member:

Reid, J. M., Canadian General Electric Co., Peterborough, Ont.

TWIN CITY SECTION

Associate Members:

Burley, W. B., G. M. Orr Engineering Co., Minneapolis, Minn.
Sallee, W. L., G. M. Orr Engineering Co., Minneapolis, Minn.
Williams, J. F., General Electric Co., Minneapolis, Minn.

WINNIPEG CHAPTER

Associate Members:

Burnard, A. C., Canadian General Electric Co. Ltd., Winnipeg, Man.
Kirkpatrick, E. T., F. D. Bolton Ltd., Edmonton, Alberta

ATTENTION MANUFACTURERS

Well established manufacturers' agency. Very thorough coverage northern Ohio. Located in Cleveland. Interested in adding good line. Address Box 148, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

SITUATION WANTED

Young Lighting Specialist, experienced in sales and layouts of commercial, residential, industrial lighting. Familiar with lamp sales procedure. Address Box 149, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

INDEX TO ADVERTISERS
November 1951

Acme Electric Corp.	37A
Art Metal Co.	11A
Benjamin Electric Mfg. Co.	Inside Front Cover
Bryant Electric Co.	14A
Certified Ballast Manufacturers	Inside Back Cover
Day-Brite Lighting Inc.	28A
Fluorescent Fixtures of California	38A
Garden City Plating & Mfg. Co.	27A
General Electric Co., Apparatus	32A
General Electric Co., Lamp	30A
Edwin F. Guth Co.	23A
Jefferson Electric Co.	29A
Leader Electric Co.	21A
Lighting Products Inc.	12A-13A
Litecontrol Corp.	2A
Meierjohan-Wengler	37A
Miller Co.	31A
Mitchell Manufacturing Co.	9A
Northern Light Co.	33A
Pittsburgh Reflector Co.	35A
Rohm & Haas Co.	24A
Sola Electric Co.	18A
Sunbeam Lighting Co.	34A
Superior Electric Co.	36A
F. W. Wakefield Brass Co.	17A
Westinghouse Electric Corp., Lamps	Back Cover
Westinghouse Electric Corp., Lighting	1A

THIS NEW BOOK

shows hundreds of decorative lighting fixtures and lanterns, for Churches, Federal and State Buildings, Banks, Schools, and Public Institutions . . . custom-made of Bronze, Aluminum, Wrough Iron and Stainless Steel, over the past quarter century, by Cincinnati's Metalcraftsmen.

Write for your free copy—for current and for future reference. Address:

MEIERJOHAN-WENGLER—*Metalcraftsmen*

1102 West 9th St. **Cincinnati 3, Ohio**

QUIET MEANS QUALITY

The core and coil assembly of an Acme Electric Ballast is made to such a high standard of excellence that normal magnetic hum is minimized and then further silenced thru impregnation. Assembly is sealed in the case, solidly imbedded in heat and cold resisting compound. Noise free operation is assured.

ACME ELECTRIC CORPORATION

2911 WATER STREET **CUBA, N. Y.**

Acme ACME Electric

it takes
ULTRA-PRECISION
and
PLENTY OF EXPERIENCE
to make better fluorescent fixtures...

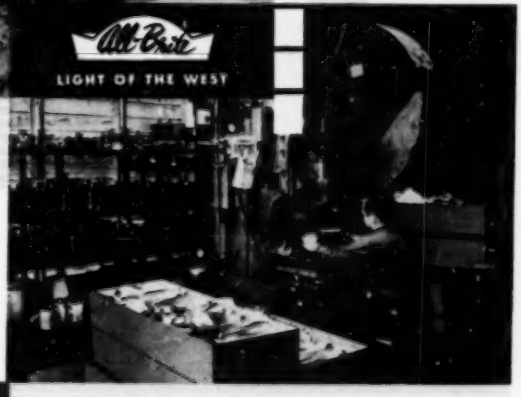
ALL-BRITE'S OWN TOOL-AND-DIE DEPARTMENT GIVES YOU BOTH

upper left: Turning stock to extra-fine tolerances on his lathe is part of this All-Brite artisan's daily work.

center: Science and art are combined by this master All-Brite tool-and-die maker in checking dimensions with extraordinarily precise instruments.

below, right: One of All-Brite's many punch presses. Rack against wall shows a section of enormous stock of costly tools and dies.

All-Brite
LIGHT OF THE WEST



another PLUS in lighting value

The degree of craftsmanship required to fabricate All-Brite quality luminaires is so exacting that tools and dies for stamping and forming are made in All-Brite's OWN modern tool-and-die shop by super-skilled experts, under the careful scrutiny of All-Brite top engineers. No wonder All-Brite fixtures are preferred in the West for efficiency, performance and durability! Write for complete catalog.

FLUORESCENT FIXTURES OF CALIFORNIA

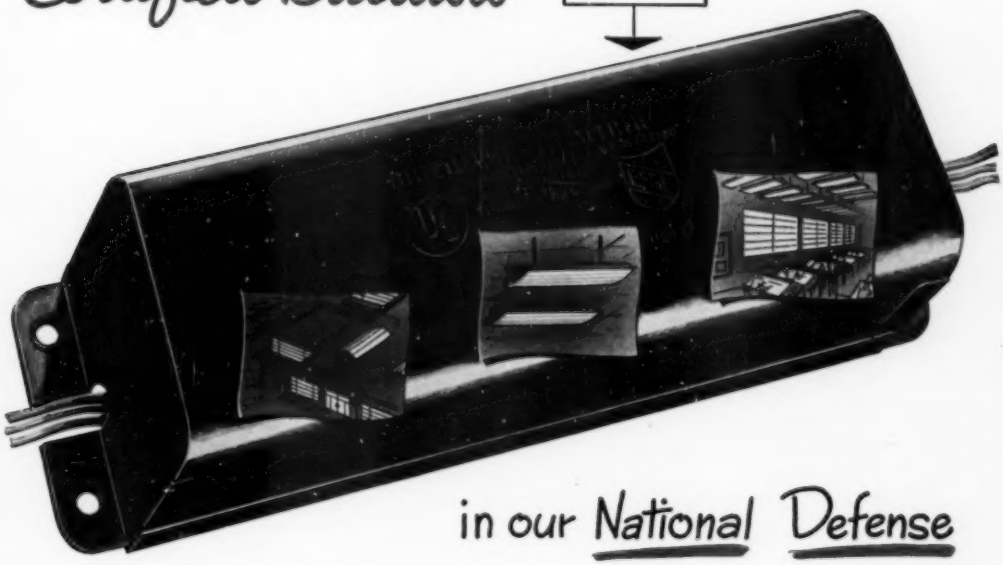
FLUORESCENT WESTERN CONTEMPORARY

THREE ALL-BRITE PLANTS:

san francisco: 3320-18TH ST.
los angeles: 613 IMPERIAL ST.
portland: 1318 S.W. FIRST AVE.

the Role of Certified Ballasts

CERTIFIED E·T·L HIGH PF



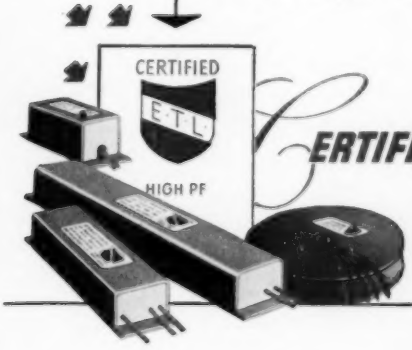
in our National Defense

The making of fluorescent ballasts uses critical materials required in our national defense program.

The Lighting Industry can best conserve available materials by using them most efficiently. To assure *long, trouble-free ballast operation, full lamp life, rated light output and satisfactory fluorescent performance,* insist on CERTIFIED BALLASTS in all fixtures.

CERTIFIED BALLASTS are tested by Electrical Testing Laboratories, Inc., which certifies they meet the precise specifications that assure efficient operation.

TO BE SURE . . . look for the CERTIFIED shield on the ballast.



Participation in the CERTIFIED BALLAST program is open to any manufacturer who complies with the requirements of CERTIFIED BALLAST MANUFACTURERS.

CERTIFIED BALLAST MANUFACTURERS

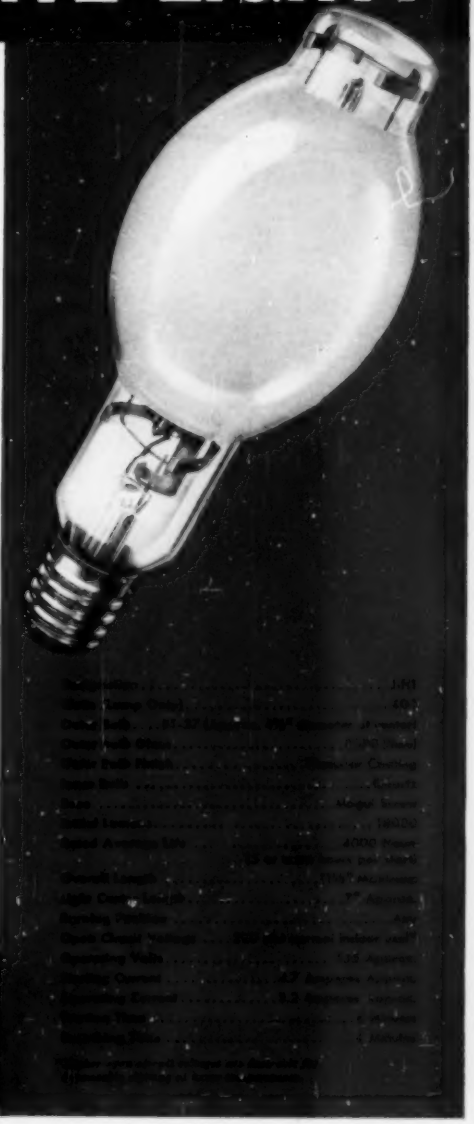
Makers of Certified Ballasts for Fluorescent Lighting

2116 KEITH BLDG., CLEVELAND 15, OHIO

NEW WESTINGHOUSE FLUORESCENT MERCURY LAMP

GIVES

GOLDEN-WHITE LIGHT!



Exclusive New Westinghouse Lamp Produces More Light of a Warmer Color Than Conventional Mercury Lamps

Here's a basic new light source—a mercury type lamp which produces a *golden-white light*—the new Westinghouse 400 watt J-H1 Fluorescent Mercury Lamp.

This outstanding new improvement is accomplished by the isothermal-shaped bulb which permits a special phosphor coating to fluoresce red at maximum efficiency. The red light balances the spectrum to provide a golden-white light. This new light source combines all the advantages of high output, high efficiency and long life, plus 20% more light than the 400-watt A-H1 lamp. In addition, higher color quality eliminates the need for color-correcting incandescent lamps. Ideal for industrial and large area outdoor lighting, the J-H1 Fluorescent Mercury Lamp can be used in the same sockets as the A-H1 or the E-H1 types without additional equipment.

For more information about the practical applications of this lamp, write the Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey.

YOU CAN BE SURE...IF IT'S

Westinghouse